

Logistics, Cycle 2 Overview, and Functional Decomposition

BME 590L

Target Specifications: What you will deliver in Engineering Language

- Translation from Customer Language to Engineering Language
- Target specifications should:
 - Be measurable (with a method that is available to you)
 - Be independent of the solution
 - Map to a customer need
 - Have an ideal value, and a target value, informed by your competitive products
- Choose wisely!
 - This is the criteria that you will be judged on at the end of the year
 - It acts as a contract and negotiation tool for you and your sponsor

Outline

- Tangent: Career stuff
- Schedule, updated
- MedX RFAs, Pitch Presentations
- Cycle 2 Overview
- Functional Decomposition

Disclaimer

“No one can give you better advice than yourself” - Cicero

Career Planning

- Recruiting for next summer has already begun!
- Job/Internship opportunities come in waves
- Expectations for a job searching:
 - Looking for a job is a part-time job (couple hours/week)
 - Expect that you'll apply to at least 20 jobs, and probably interview with 2-3 before you find your first job
 - I did 30+ Informational Interviews and applied to 10+ jobs before finding one...

The Need: Focus

- Which industry?
- What kind of company?
- What role?
- What location?

Quote from Clayton Christensen

“There are direct paths to a successful career. But there are plenty of indirect paths, too. So many young people I speak to nowadays think that the only way to get to such a career is by the direct path; but that really only makes sense in certain circumstances. If you've found something that you love, that motivates you and that pays the bills, then a direct path works well. But if you haven't, don't settle. The indirect path can be just as effective at getting you there.”

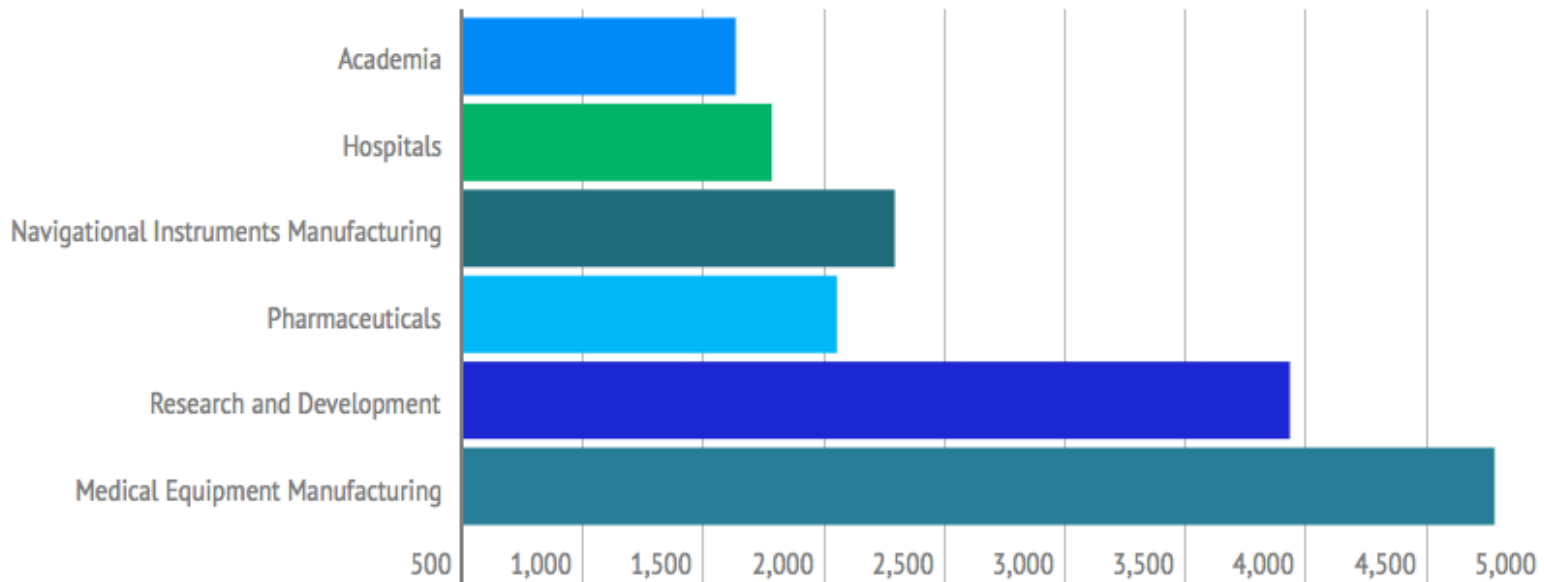
<https://www.forbes.com/sites/danschawbel/2012/06/05/how-will-you-measure-your-life/#69b5069d4d09>

Which Industry?

- Medtech (Medtronic, St. Jude)
- Biotech (Genzyme, Genentech)
- Pharma (Merck, Pfizer)
- NGO (Gates Foundation, PATH)
- Gov't (FDA, USPTO)
- Management Consulting (McKinsey, BCG)
- Many others (Oil/Gas, Law, Investing, etc)

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Employment in Bioengineering

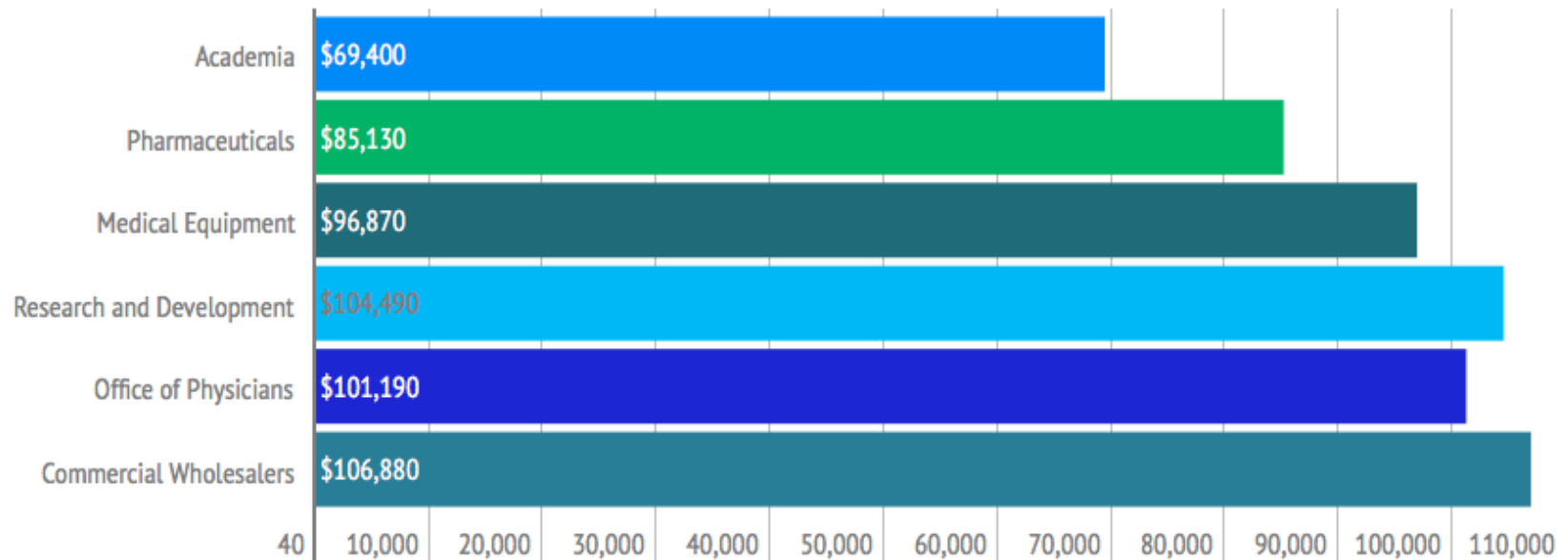


Employment in selected Biomedical Engineering industries, May 2015

Source: U.S. Bureau of Labor Statistics

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Biomedical Engineering Salaries



Annual mean wage of selected Biomedical Engineering occupations/industries, May 2015

Company Size

- What have you heard are pros/cons about large and small companies?
- Large Companies:
 - More specialized role, but you may support several products
 - Broader network of people
 - Slower pace (maybe!)
 - Development and lateral move opportunities
- Smaller Companies
 - Wear many hats
 - Typically focused on one product
 - Fast-paced, high-risk, high-reward
 - Potential for fast growth, leadership positions

Which Role?

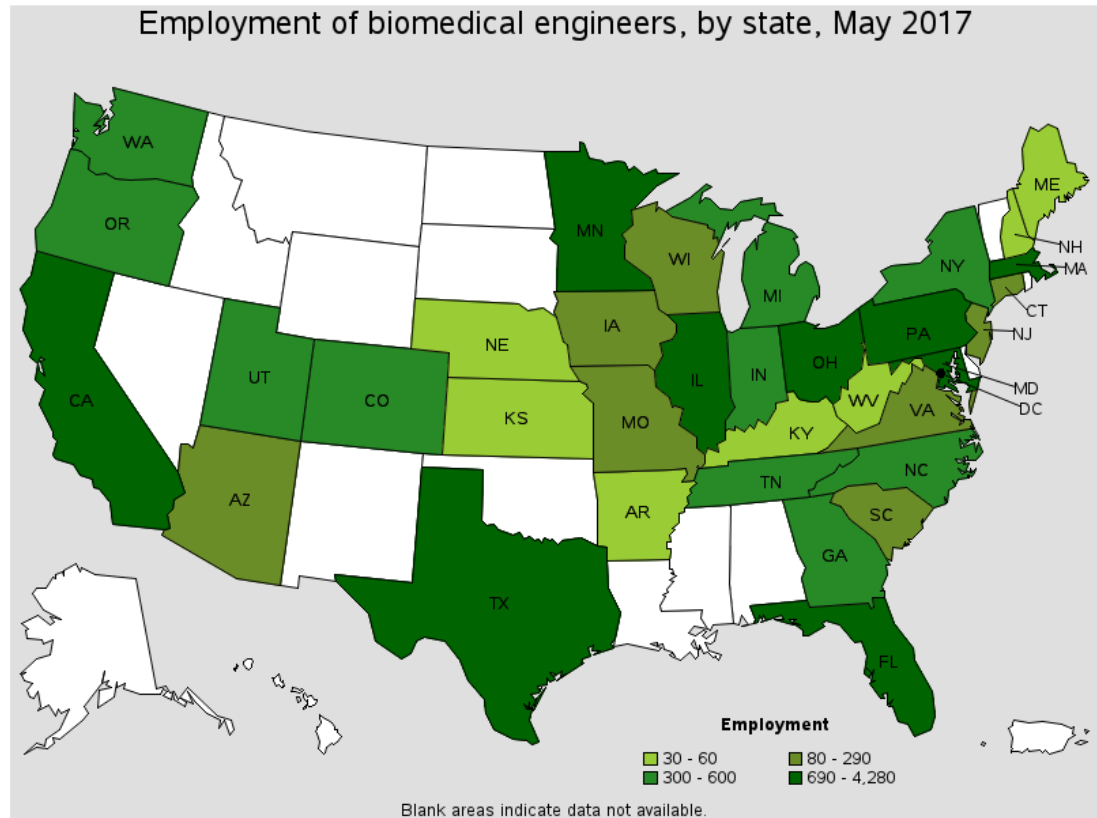
- (Advanced) Manufacturing Engineer
- Design Assurance Engineer
- Clinical Field Engineer
- R&D Engineer
- Scientist
- PD Engineer
- Systems Engineer
- Marketing Associate
- Business Development
- Regulatory Affairs Specialist
- Training and Education Specialist
- Sales Representative
- Program Manager
- Microbiologist

Lists of companies:

- <http://www.mddionline.com/article/top-40-medical-device-companies>
- <http://massdevice.jobamatic.com/a/jbb/find-jobs>
- <http://www.qmed.com/mpmn/medtechpulse/top-10-states-medtech-infographic>

Geographic Options

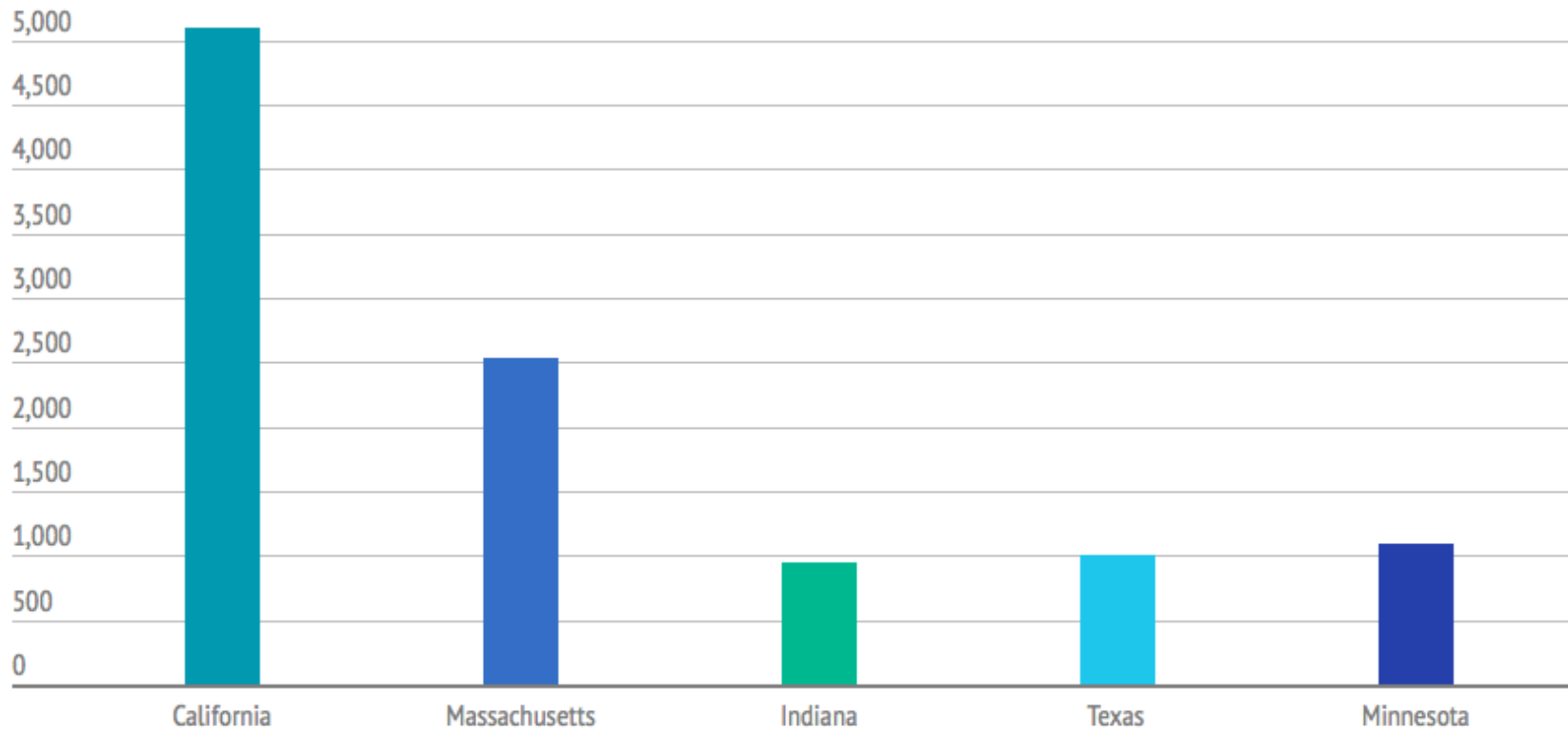
- Local (Pros/Cons)
- National (Pros/Cons)
- International (Pros/Cons)



States with the highest employment level in this occupation:

State	Employment (1)	Employment per thousand jobs	Location quotient (9)	Hourly mean wage	Annual mean wage (2)
California	4,280	0.26	1.82	\$49.87	\$103,730
Massachusetts	2,520	0.72	5.07	\$45.36	\$94,360
Illinois	1,330	0.23	1.60	\$47.60	\$99,000
Minnesota	1,300	0.46	3.24	\$52.06	\$108,290
Texas	1,030	0.09	0.62	\$45.67	\$94,990

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This chart shows the states with the highest levels of employment in Biomedical Engineering in 2015. These states are among the highest receivers of R&D awards from the National Institutes of Health, the largest source of medical research funding in the world.

Educational Level

“Biomedical engineers typically receive greater responsibility through experience and more education. To lead a research team, a biomedical engineer generally needs a graduate degree.” -US BLS

Education Level

- Entering industry with:
 - Bachelor's Degree
 - Can be challenging to land a job, but many large companies have programs for undergraduates
 - Master's Degree
 - Most common for Medtech, many go back and get a Masters if they don't have it
 - PhD
 - Somewhat common in Biotech (less common in Medtech), helpful in R&D and clinical roles

Masters Programs for Industry

- Hopkins CBID
- Berkeley MTM
- Duke MEng
- GA Tech
- Others: Northwestern, U Cincinnati, U of MN, U Mich, etc.
- U Wash, UCSD – great for Biotech
- Advice: Apply for programs as a backup option! (some apps due in Dec/Jan)
- Think about location as well as the program

Last words of advice

- After considering all these elements, narrow your search down to a handful of companies
- Search their websites for info/opportunities
- Know and use LinkedIn groups to look for Duke Alumni or other connections who work there
- Consider applying for both jobs and MS programs
- Reach out and start informational interviewing!
- Happy to meet and review resumes/LinkedIn profiles

Some Other Resources

- Medgaget.com
- Massdevice.com
- Advamed.org
- <http://medcitynews.com>

Schedule Review

Cycle One: Need Finding

- Purpose of our cycle one:
 - Validate it's really a problem no one has solved
 - Helps you gain a deeper understanding of the problem so you are better-equipped to design
 - Motivation
- Everyone experiences re-scoping, clarification, pivots during this phase
- Not necessarily the “business side” but just the (un)common sense of engineering
- Challenging, but real-world prep

Project Pitches, post documentation and BMES

- Each cycle has documentation and a presentation (both are building blocks of final documentation and final presentation)
- Dr. Walker will be coming to talk about the format of your presentation on Thursday
- 10 minute “pitch”, essentially our DFD condensed in <10 slides

MedX RFAs

- Teams will have a number of opportunities to submit applications for grants, design competitions, BP competitions, etc.
 - Documentation has been developed so you can cut and paste for these applications
 - Great opportunities to showcase your work and/or gain recognition for jobs, grad school, med school
- Opportunity #1: MedX RFAs
 - DFD plus abstract/summary file (1 page limit) that includes:
 - the project title
 - a brief summary or abstract
 - a list of team members names, departmental affiliation, major field(s) of study, and level of training (e.g. undergrad, Masters or PhD student)
 - Due same day as cycle 1 documentation

	Start of Course	Fall Break	Winter Break	Spring Break	End of Course
Lecture Topics	Cycle 1 - PREP/ID Disease State Analysis, Patient Flow Competitive Options, including IP landscape Market Analysis Customer Needs Specifications, Constraints (including Standards/reg)	Cycle 2 - DESIGN Functional Decomposition and System-level Design Concept Generation Concept Selection Testing strategies Two "concept feedback" lectures	Cycle 3 - PROTOTYPE DFM, LBM Quality: DOE, Statistics, FMEA Clin/Reg Strategy and IRB IP Disclosure and Strategy	Cycle 4 - TESTING Design Poster Presentations Oral Presentation Tips & Tricks Final Presentation Dry-runs	
Written Deliverables	Design Foundation Document, which includes DSA, Patient Flow, IP, Market Analysis (Basically the intro section to the final report) HOQ (Customer needs mapped to preliminary specifications and constraints)	Functional Decomposition (Appendix 1 of Final Report) Sketches/CAD of top designs (Appendix 2 of Final Report) Pugh Matrices (Appendix 3 of Final Report) Updated HOQ/specs Testing Strategy (rough proposal) Rev 2 of DFD	Final design description (both form and function, including CAD/photos of prototype) Testing proposal (essentially the methods section of final report) Implementation Strategies (LBM, FMEA, Clin/reg strategy and IRB proposal (if needed)) Updated, Final HOQ/specs Rev 2 of Appendices Competition Submission Plan	Final Report, which includes: 1) DFD 2) HOQ 3) Final Design Document 4) Test Methods and Results 5) Implementation Strategies 6) Appendices Competition Submission IP Disclosure (if applicable) IRB documentation (if applicable)	
Presentation Deliverables	Project Intro slides (content of DFD, up to specs), 10 slides	Intro slides, plus five slides showing top 3 concepts/prototypes/subfunctions (Video/photos/CAD encouraged)	Intro slides, final design slides (3-4 slides showing final prototype), and implementation slides (3-4 slides showing LBM, FMEA, Clin/reg strategy)	Final Presentation (Intro slides, final design slides, testing results, implementation slides, conclusion slides - polished) Poster Presentation (leveraging their existing slide deck and final report)	
Presentation Format	10 minutes in-class presentation	30 minute time slot, with mentors and part of class (four other teams?)	15-20 minute in-class presentation	30 minute time slot, with mentors and part of class (four other teams?)	
Prototyping	Prototyping skills introduced	Initial prototyping; low to medium fidelity prototype and/or working subfunctions completed by winter break	Prototype refinement; functional, integrated prototype ready by spring break	Prototype tested against all specs in a statistically-driven approach	

Cycle 2: Let design begin!

- Concept generation, concept selection, prototyping
- (Formal) Documentation-lite
 - Cycle 1 documentation being finished/polished in the background
- Output: Medium-fidelity (rough) prototype of top concepts or subcomponents
 - Can you convince yourself (and us) that it's feasible, and that you can complete a fully functional prototype by Spring Break?

Functional Decomposition

- At the heart of most formal design approaches
- Especially useful for “grassy field” problems with no existing solutions
 - Often not used for very simple designs, or modifications of existing ones
 - Even for existing solutions, can help create fresh approaches
- The best format of your functions will be dictated by the particulars of your project.

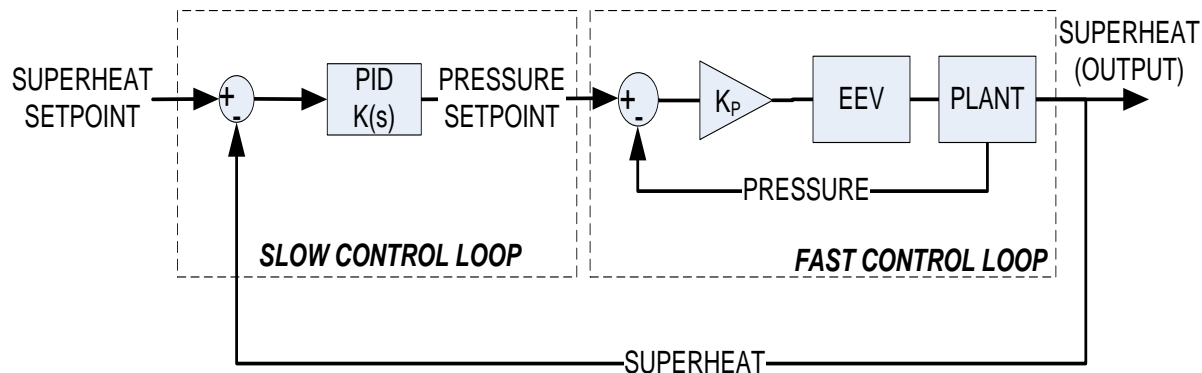
Functional Decomposition, cont.

- Best to start with a need statement
- Break up this problem statement into required individual functions, which describe what needs to be achieved in plain language (hint: use your specs)

Example: Four functions of a control system

Need: There is a need for a controller to force a dynamic system to maintain a specific operating state in the presence of disturbances.

1. **Measure** where you are.
2. **Compare** where you are to where you wish to be.
3. **Calculate** what to do about it.
4. **Apply** effort to bring system being controlled to desired point.



Example: Four functions of a control system

- Note nothing is said about sensors, computers, actuators, mechatronics, PID, ladder logic, PLC, etc.
- Functions of this type are generally expressed as a sentence with a verb and object.
- This approach allows for a wider solution space—helps prevent tunnel vision during the concept generation phase of the design.

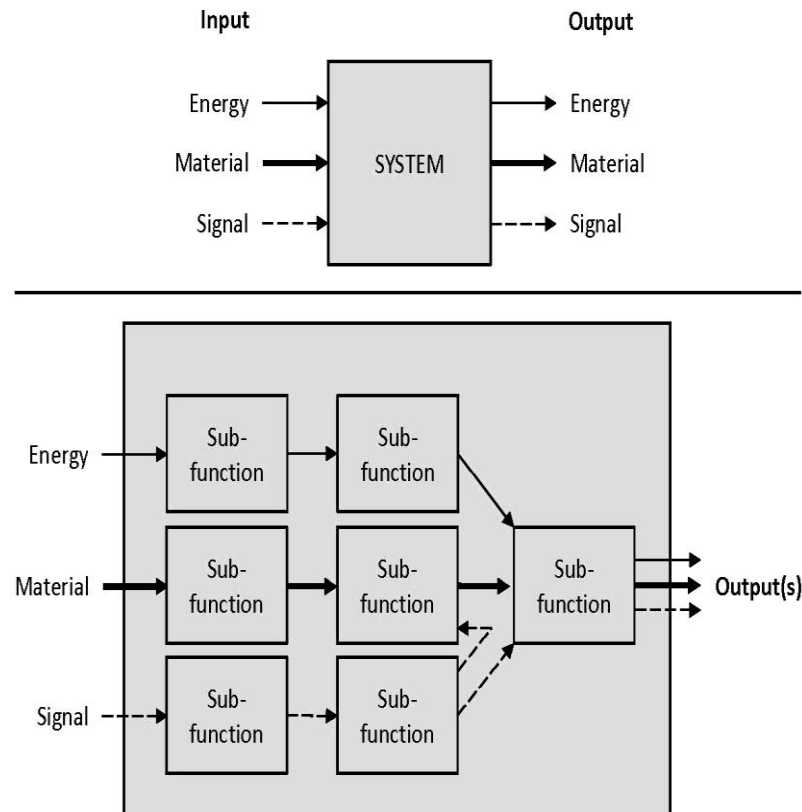
Example: Four functions of a control system

- Consider a Napoleonic era man-of-war:
 - **Measurement** of location done by midshipman using sextant
 - **Comparison** performed by navigator using charts
 - **Calculation** of course adjustment performed by navigator and captain
 - **Application** of effort generated by captain issuing orders to crew

Example: Four functions of a control system

- Consider a Pacemaker:
 - *Measurement*
 - *Comparison*
 - *Calculation*
 - *Application*

The Ulrich & Eppinger text uses a “black box” approach to Functional Decomposition. Very well suited for process design or system-level design.



Functional Decomposition

- Start with what you're trying to achieve (need statement)
- Think in terms of ***functions*** (what needs to be done?) not ***technologies*** (how am I going to do it?)
- Every industry, company, and discipline has its own specific approach to functional composition that is most useful to its own best practices
- No one-size-fits all approach, but the basic idea is widely applicable—adapt as needed!

Functional Decomposition can be “System Design” in and of itself...

- May be helpful to consider multiple decompositions
- Will get more detailed as you design your system
- Should be fluid, constantly updated, but gives you a place to start.

Class exercise (First Individually, then as a group)

- Using your need statement, develop a set of functions that a successful design will have to meet
- Can any of your functions be broken down further into subfunctions?
- Map these into a black-box diagram

Summary

- Continue work on DFD
- Think about functional decomposition
- On Thursday:
 - Edwards Lifesciences
 - Dr. Bill Walker, pitch presentations

Appendix: Other career slides

“Tracks”

- During your first 1-2 years at a big company, you may be placed on a “track” (e.g. Individual Contributor, People Manager, Project Manager) – These first years are key!
- Make it known to HR, your boss, and take initiative to move towards a track
- Get a mentor within your desired track
- Usually (not always) harder to move from individual contributor track to management track than vice versa

Know Thyself

- Myers-Briggs Assessments
 - <http://www.16personalities.com/free-personality-test>
- Strengths Finder
- Big 5
- Color Personality Test
- May be helpful, but no always accurate

Some career search advice ...

- What is the difference between a CV and a Resume?

From Rice CCD

““What’s the difference between a CV and a resume?
A curriculum vitae (CV or vita) should tell the reader what you know; a resume should tell the reader what you know how to do. A resume summarizes your background and experience in order to demonstrate your ability to do well in a specific position. A CV is a longer and more detailed document that focuses more exclusively on your academic training and related pursuits in order to demonstrate your potential as a scholar or researcher. Typically, you’ll need a CV if you’re applying for an academic position (e.g., a position at a college, university, or research institution); you’ll need a resume if you’re applying for a non-academic position in the private or public sector. Because of these distinctions, CVs and resumes tend to be phrased and organized differently.”

Paraphrasing from Medtronic/Cyberonics last year

- I literally have 1-2 minutes to look at a resume
- What I look for is experience, not necessarily education or courses
- I don't read cover letters

Grammar and Spelling

- One error can be the death of a resume.
- Use commas correctly.
- Watch out for capitalization (of your major, companies, etc.)
 - For example, accounting, business management, and event planning are not capitalized (p. 223).
- Make sure bullet points have parallel construction.

Resume

- “It’s not how fancy it is, it’s how clear, clean and elegant it is in it’s simplicity” -
<https://hbr.org/2014/12/how-to-write-a-resume-that-stands-out>
 - Open strong
 - Get the order right
 - Be selective
 - Share accomplishments, not responsibilities
 - Make it readable
 - Get help
 - Tweak it for each opportunity
 - Align with your LinkedIn profile

Example Resumes

- <http://career-advice.monster.com/resumes-cover-letters/resume-samples/sample-resumes-by-industry/article.aspx#Engineering>

Two Great Resources

- Building a great Student Profile
 - [http://ccd.rice.edu/uploadedFiles/CCD/Students/How%20to%20Build%20a%20Great%20Student%20LinkedIn%20Profile\(1\).pdf](http://ccd.rice.edu/uploadedFiles/CCD/Students/How%20to%20Build%20a%20Great%20Student%20LinkedIn%20Profile(1).pdf)
- LinkedIn Etiquette
 - [http://ccd.rice.edu/uploadedFiles/CCD/Students/QA-%20LinkedIn%20Etiquette\(1\).pdf](http://ccd.rice.edu/uploadedFiles/CCD/Students/QA-%20LinkedIn%20Etiquette(1).pdf)

Other Resources/Tips

- Make your profile public, but not your activity (People can see you)
- Watch out for automatic invites!
- More on LinkedIn Etiquette:
<http://mashable.com/2014/01/18/linkedin-etiquette/>
- Endorsements: <http://www.tnj.com/career/career-advice/making-most-your-linkedin-endorsements>
- <https://www.zionandzion.com/10-best-practices-for-linkedin/>
- [CCD has great resources and gives workshops:](#)
 - <http://ccd.rice.edu/students/resources/>

Informational Interview Networking

- Connect with the Duke Group and Duke Alumni group on LinkedIn
- Reach out to people at companies you are interested in, ask for 15-20 min of their time
- Ask them sincere questions about their career path, current role, company, etc.
- Ask them if there is anyone else who can provide their perspective
- Send them a thank you note with your resume