ECE 411
Engineerng Practices
Decision Making

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"Making good decisions is a crucial skill at every level. It needs to be taught explicitly to everyone in organizations that are based on knowledge."

-- Peter Drucker

Decision Making

- Many engineering tasks require deciding among several alternatives
  - Picking a capstone project
  - Choosing which of several product ideas to pursue
  - Deciding among several different design alternatives
  - Selecting components or subsystems
  - Evaluating job opportunities
  - Choosing a vendor
- Will explore three techniques
  - Decision matrix
  - Analytical Hierarchy Process (AHP)
  - Pareto charts

"When choosing between two evils, I always like to try the one I've never tried before."

-- Mae West

Decision Matrix

		Alternative 1	Alternative 2		Alternative n
Criteria 1	ω_1	α_{11}	α_{12}		α_{1n}
Criteria 2	ω_2	α_{21}	α_{22}		α_{2n}
$\vdots$	$\vdots$				
Criteria *m*	ω_m	α_{m1}	α_{m2}		α_{mn}
Score		$S_1 = \sum_{i=1}^{m} \omega_i \alpha_{i1}$	$S_2 = \sum_{i=1}^{m} \omega_i \alpha_{i2}$		$S_n = \sum_{i=1}^{m} \omega_i \alpha_{in}$

Example: Choosing A New Laptop

		Dell	Toshiba	Lenovo
Cost	**5**	5	1	3
Weight	**3**	3	5	4
Battery Life	**3**	3	3	4
Screen Size	**4**	3	4	4
Disk Capacity	**2**	4	3	3
Score		63	61	51

Decision Matrix Process

1. Determine the selection criteria
   - Relevant to the objective
2. Determine the criteria weightings
   - Relevant to the objective
3. Identify alternatives
   - May be given, may require research to identify
   - Some may be excluded due to binary criteria (e.g. "must have …")
   - Document these to indicate why they weren't considered
     - May reconsider importance of "must have…"
     - Alternative may satisfy requirement in future
4. Rate alternatives relative to the criteria
   - Requires numerical framework for criteria
   - Requires means to assign numerical value to an alternative
   - Requires research
   - May rely on estimates, incomplete knowledge
     - Be careful if highly weighted!
5. Compute scores for the alternatives
6. Review the decision

Example: Selecting A Product Idea

1. Determine the selection criteria
2. Determine the criteria weightings
3. Identify alternatives
4. Rate alternatives relative to the criteria
5. Compute scores for the alternatives
6. Review the decision

Criteria	Wt
Estimated gross profit	
Estimated (ROI)	
Estimated available market size	
Estimated 1st year market share	
Estimated 5th year market share	
Stability (resistant to recession)	
Competition	
Product leadership	
Customer acceptance	
Influence on other products	
Manufacturing content	
Patent position	
Sales force qualification	
Time to introduction	
Technical ability to develop	

Example: Selecting A Product Idea

1. Determine the selection criteria
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Criteria	Wt
Estimated gross profit	2
Estimated (ROI)	1
Estimated available market size	2
Estimated 1st year market share	1
Estimated 5th year market share	1
Stability (resistant to recession)	2
Competition	1
Product leadership	1
Customer acceptance	1
Influence on other products	1
Manufacturing content	1
Patent position	1
Sales force qualification	1
Time to introduction	2
Technical ability to develop	1

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Product A	Product B	Product C

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Criterion	1	2	3	4	5
Estimated (ROI)	<60%	>60%	>70%	>80%	>90%
Competition	2 strong	1 strong	2 weak	1 weak	none
Patent position					
Technical ability					

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Considerations	wt. Factor	Excellent 5	Above average 4	Average 3	Below average 2
Est. gross profit	2	50% and over/yr.	49–30%/yr	29–20%/yr	19–10%/yr
Est. IROI	1	90% and over	89–75%	74–60%	59–39%
Current annual available business	2	$10 million +	$10–$7.5 million	$7.5–$5.million	$5–$2.5 million
Market potential 5 yr.	1	In growth stage. Increasing sales & demand at an increasing rate	Reaching maturity. Increasing sales but at a decreasing rate	Turning from maturity to saturation. Leveling of sales	Declining sales & Profits
Est. market share 1 yr.	1	25% and over	24–15%	14–10%	9–5%
Est. market share 5 yr.	2	50% and over	49–30%	29–20%	19–10%
Stability	1	Product resistant to economic change	Some resistance to economic change and out of phase	Sensitive to economic change—but out of phase	Sensitive to economic change and in phase
Degree of competition	1	No competitive products	Only slight competition from alternative	Several competitors to different extents	Many competitors
Product leadership	1	Fills a need not currently satisfied. Is original	Improvement over existing competition	Some individual appeal, but basically a copy	Barely distinguished from competitors
Customer acceptance	1	Readily accepted	Slight resistance	Moderate resistance	Appreciable customer education needed
Influence on other products	1	Complements and reinforces an otherwise incomplete line	Easily fits current line, but not necessary	Fits current line, but may compete with it	Competes with, and may decrease sales of current line
Manufacturing content	1	Completely manufactured in-house	Partially mfg'd, assembled & packaged in-house	Assembled and packaged in-house	Packaged in-house
Patent position	1	Impregnable. Exclusive license or rights	Some resistance to infringement, few firms with similar patents	Probably not patentable; however, product difficult to duplicate	Not patentable, can be copied
Sales force qualification	1	Qualified sales force available	Sales force has basic know-how. Minor product orientation required	Sales force has basic know-how, requires product and application education	Sales force requires extensive product and application education
Time to introduction	2	Less than 6 mo.	6-12 mo.	12-24 mo.	24-36 mo.
Technical ability to develop and produce	1	Present technical know-how available and qualified	Most technical know-how available	Some know-how available	Extensive technical support required

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Analytical Hierarchy Process (AHP)

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Analytical Hierarchy Process (AHP)

Problem: Select a new car to purchase

1. Determine the selection criteria
2. Determine the criteria weightings
3. Identify alternatives
4. Rate alternatives relative to the criteria
5. Compute scores for the alternatives
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Selection Criteria
Purchase cost
Safety
Design styling
Brand name recognition

Analytical Hierarchy Process (AHP)

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Pair-wise comparison of each criterion for relative importance

1 – equal
3 – "moderately" more important
5 – "strongly" more important
7 –" very strongly" more important
9 – "extremely" more important

Reciprocal (1/n) for less important

	Price	Safety	Design	Brand
Price	1	1	3	7
Safety	1	1	5	9
Design	1/3	1/5	1	3
Brand	1/7	1/9	1/3	1

Analytical Hierarchy Process (AHP)

- Can lead to mutually inconsistent results
  - Price and Safety of equal importance, but
  - Safety:Design = 5
  - Price:Design = 3
- Need to "normalize" to make valid comparison
- Requires geometric mean

$$Geometric\ Mean = \sqrt[n]{\prod_{i=1}^{i=n} x_i}$$

$$Weight_{row} = \frac{Geometric\ Mean_{row}}{\sum_{r=1}^{r=n} Mean_r}$$

$\sqrt[4]{1 \times 1 \times 3 \times 7} \cong 2.1$

$2.1 + 2.6 + 0.7 + 0.3 = 5.7$

$\frac{2.1}{5.7} = 0.37$

	Price	Safety	Design	Brand	Mean	Weight
Price	1	1	3	7	2.1	0.37
Safety	1	1	5	9	2.6	0.46
Design	1/3	1/5	1	3	0.7	0.12
Brand	1/7	1/9	1/3	1	0.3	0.05
					5.7	

Analytical Hierarchy Process (AHP)

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Example: Choosing Among Several Product Ideas

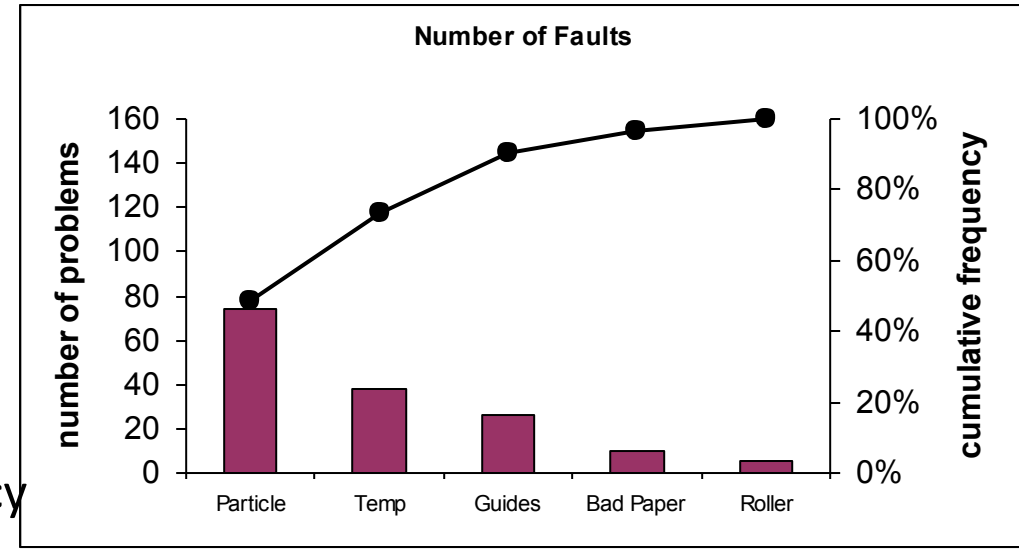
- Related to ethics
  - Who are the stakeholders?
  - What are their objectives
  - How are they affected?
- Impact
  - How can this product be used/misused?
    - Encryption, Peer to peer services
    - Radar detectors, DIY Bio
- Unintended consquences
  - Internal combustion engine and the automobile
    - Freeways
    - Suburbs
    - Annual traffic fatalities
    - Pollution
    - Global warming
    - Fossil fuel dependence
    - National security
  - Mobile phones, texting
    - Train, auto crashes

Pareto Charts

In 1897 Vilred Pareto, an Italian economist, was studying the distribution of wealth in Italy and found that a large percentage of the wealth was concentrated in about 10% of the population. This became known as Pareto's Law. Shortly after WW II, inventory analysts noticed that about 20% of the items in inventory accounted for 80% of the dollar value. In 1954 Joseph Juran generalized Pareto's Law as the "80/20 Rule": "80% of sales are generated by 20% of the customers", "80% of product defects are caused by 20% of the components", etc. Juran summarized this in the admonition to "concentrate on the vital few and not the trivial many".

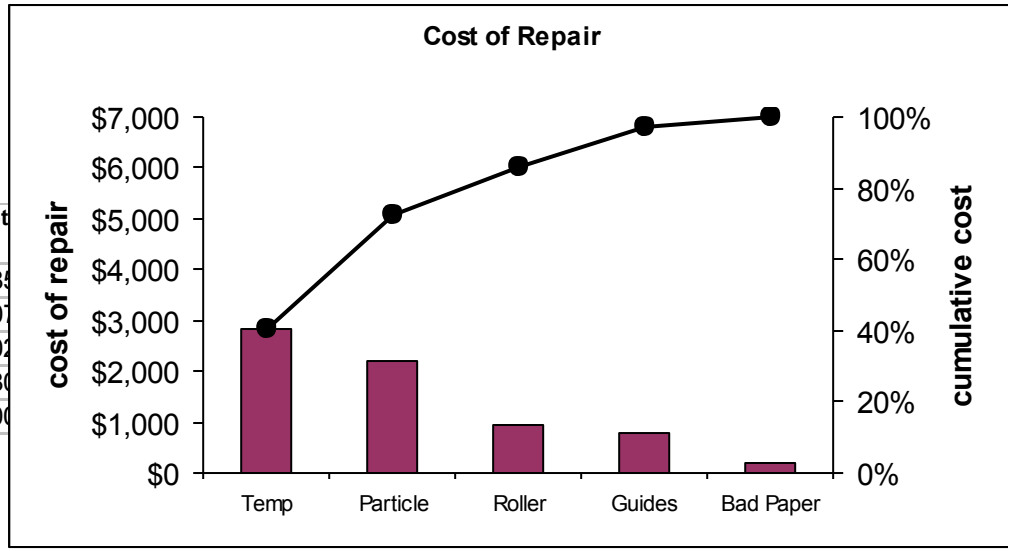
An Example: Copier Breakdowns

		Faults	Cum Faults	%
paper particle buildup	Particle	74	74	48%
excessive temperature	Temp	38	112	73%
guides misaligned	Guides	26	138	90%
defective paper	Bad Paper	10	148	97%
worn roller	Roller	5	153	100%



- Histogram
- Sort from highest to lowest frequency (or other metric)
- Include cumulative %
- Measure the right thing!

		Faults	Cost/fault	Total Cost	Cum Tot Cost
excessive temperature	Temp	38	$75	$2,850	$2,85
paper particle buildup	Particle	74	$30	$2,220	$5,07
worn roller	Roller	5	$190	$950	$6,02
guides misaligned	Guides	26	$30	$780	$6,80
defective paper	Bad Paper	10	$20	$200	$7,00



Pareto Charts

- Product Ideas
  - Rank by weighted evaluation score
- Manufacturing Quality Management
  - Defects
  - Root cause for field returns
- Cost Reduction
  - Identify highest price components/subsystems
- Program Optimization
  - Identify functions/methods using most time
- Software Improvement
  - Source of bugs found (e.g. “coding”, “memory”, “spec”)