

## Realistic Constraints in Design

### **Mechanical Engineering Program Outcome (c):**

Students from the Mechanical Engineering program will attain (by the time of graduation): an ability to **design** thermal, fluid, and mechanical systems, components, or processes **to meet desired needs within realistic constraints** such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

In addition to the traditional technological and economic considerations fundamental to the design of mechanical components and systems, the modern engineer has become increasingly concerned with the broader considerations of **realistic constraints** which are particularly related to the better-off today's society and quality of life. The additional task challenges the engineers to assemble all pertinent facts, and then to make good decisions through better understanding, imagination, ingenuity, and judgment.

For your final design, you must be imaginative and ingenious enough to anticipate potentially hazardous situations and all the factors relating to the product and make the best design decision to address those **realistic constraint issues**. You also need to check government and industry **codes and standards** and the pertinent technical literature to be sure that legal requirements are complied with.

### Economic:

- Prices of current related or similar products on market and your cost and profit
- Available budget
- Potential impact to the local and US economy
- Designs for public use need to consider high maintenance cost
- Both over design and under design cost money

### Environmental:

- Vibration induced noise to workers and product users
- Vibration induced noise to the public: large power transformers, road lamps
- Air pollution: use electric or hybrid engines
- Water pollution: toxic waste into river
- Landscape: plastic bags, computer cases
- Global warming: temperature control of exhaust gas
- Manufacturing waste collection and processing
- Space debris
- Control of energy saving devices

### Social:

- Designs in favor of certain people but against others
- worker union versus employer
- Government codes are to protect society

### Political:

- Designs using software/hardware developed under public funding
- Products (e.g., computer games, marks on clothes) that profile negative sides of a specific race or gender
- Products for use in space use on-earth patent protected designs/concepts
- Products for customers who are against US
- Products that are against US homeland security
- Products that are physically and/or mentally destructive for people

### Ethical:

- Designs without considering safety and health of workers, consumers, and/or the public
- Products implicitly using patent protected designs/concepts
- Products use radioactive materials
- Products use materials that have better appearance but are toxic
- Under design for profit
- Products for secrete survey of personal private life

### Health and Safety:

- Safety of workers and consumers
- Safety of the public
- Noise causes hearing loss
- Hazardous materials and environment for workers
- Products require the use of radioactive materials
- Products use materials that have better appearance but are toxic
- Products for infants/children require special safety considerations
- Design of a control system with acceptable stability margins for machinery where safety is of concern

### Manufacturability:

- Designs with an impossibly small manufacturing tolerance
- Designs with a required highly accurate first natural frequency
- Designs with an impossibly high stiffness
- Designs with a zero-friction contacting surface
- Designs with a no-mass part
- Perpetual machine
- Machines without vibration
- Can the proposed material be welded if welding is the proposed assembly method?
- Is the product's surface paintable if it is designed to have an artificial color?
- No gravity for manufacturing process in space
- Availability of chosen material
- Titanium alloy and ceramics require special cutting tools
- Design of a control system which is physically realizable with manufacturing constraints such as amplifier saturation and bandwidth

**Sustainability:**

- Can the business survive?
- A well defined life span under the assumed normal operation conditions
- Consideration of actual environmental factors (extreme working temperature, corrosive fluid, abrasive air, severe radiation in space, etc.) in design
- All parts need to have a similar designed life span
- Machines require perfect suppression of vibration to function
- Reliability and durability of the product's supposed function

**Legality:**

- Products using concepts protected by patents
- Design by following required codes
- Products for secret survey of personal private life
- Radar detection devices for cars

**Inspectability:**

- Designs can be inspected during maintenance service
- Designs are easy for system health monitoring

## Web Sites for Public Codes and Standards

**DoE Status of State Energy Codes (HVAC):**

[http://www.energycodes.gov/implement/state\\_codes/index.stm](http://www.energycodes.gov/implement/state_codes/index.stm)

**EPA (health):**

<http://www.epa.gov/>

**Noise Control Codes:**

<http://www.portlandonline.com/bds/index.cfm?&a=18493&c=38052>

**Thermal Pollution (environmental):**

[http://www.esmagazine.com/CDA/ArticleInformation/features/BNP\\_Features\\_Item/0,2503,132219,00.html](http://www.esmagazine.com/CDA/ArticleInformation/features/BNP_Features_Item/0,2503,132219,00.html)

**US Government web portal:**

<http://www.firstgov.gov/>

**Occupational Safety & Health Administration (U.S. Department of Labor):**

<http://www.osha.gov/>

**U.S. Consumer Product Safety Commission:**

<http://cpsc.gov/>

**American National Standards Institute:**

<http://www.ansi.org/>

**A National Resource for Global Standards:**

<http://www.nssn.org/>

**National Institute of Standards and Technology:**

<http://www.nist.gov/>

**ASME Codes & Standards:**

<http://www.asme.org/Codes/>