CO2 Dragster

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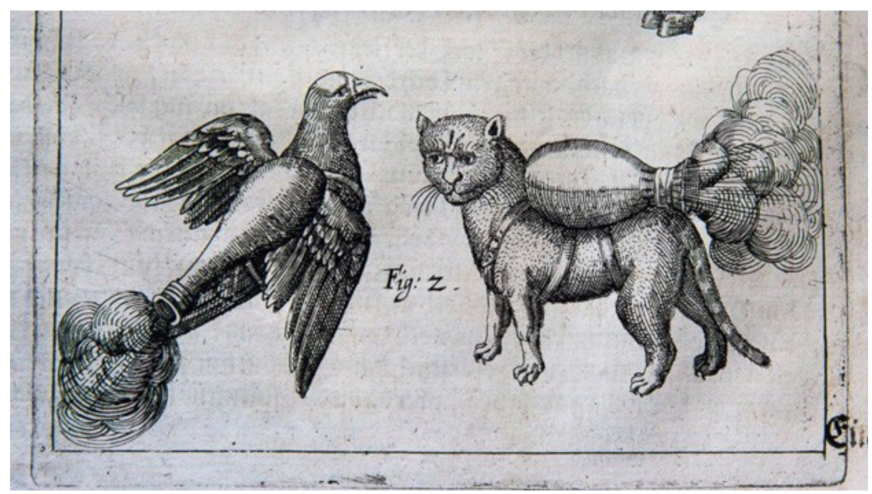
Introduction

- **Objective**: Your mission is to create the fastest 'rocket' powered animal on 4 wheels!
- You will be supplied with a 'chunk' of wood (12 x 1 5/8 x 2 3/4) that you will transform into your CO_2 powered dragster.



Introduction

- **Objective**: Your mission is to create the fastest 'co2' powered dragster on 4 wheels!
- It should minimize forces such as Gravity and Friction!
- You will be supplied with a 'chunk' of wood (12 x 1 5/8 x 2 3/4) that you will transform into your CO2 powered dragster.

RACE DAY!

- CO_2 Cars are set up
- Cars ride on guide guide lines from start of track to end of track
- CO_2 cartridge is punctured –propelling car forward
- Two cars race
- Race time is recorded for each car
- Elimination!

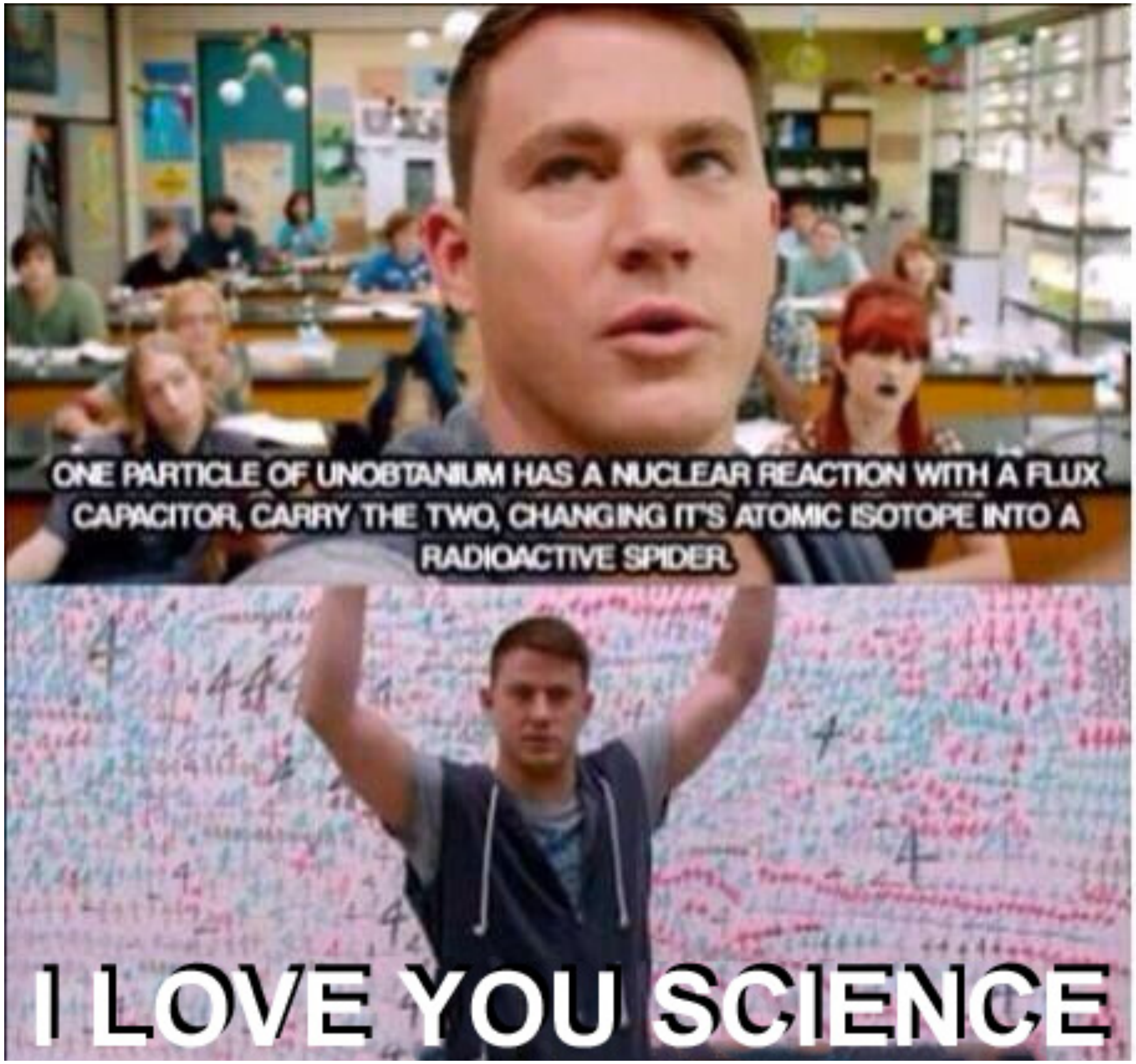
- What might look cool might not function well.
- Generally, the two best indicators of a good car are clean aerodynamics and high build quality. Often, really good designs that are built poorly will loose to so-so designs built well.
- The best design is the one that ____WINS!____. There is no "one design" that is best.

Topics for today!

- Examples of cars
- 5+ step design process
  - Our process vs real life design process
  - Cyclical Design process examples

What is CO_2?

- Power is created by CO_2 gas Propulsion. The gas is stored in the metal cartridges
- CO_2 is the chemical abbreviate for Carbon Dioxide. Not to be confused with the poisonous ___________________ (CO)
- Carbon Dioxide is made up of ______ Oxygen atoms and ______ Carbon atom sharing electrons


ONE PARTICLE OF UNOBTANIUM HAS A NUCLEAR REACTION WITH A FLUX CAPACITOR, CARRY THE TWO, CHANGING IT'S ATOMIC ISOTOPE INTO A RADIOACTIVE SPIDER.
I LOVE YOU SCIENCE

Engineering Principles

- The following Engineering Principles relate to how and why a CO2 car work
- ___________________
- ___________________
- ___________________

Mass

- The Balancing Act:
- – Advantages: Cars with less mass go much _____________.
- – Disadvantages: Cars with less mass are less ______________ and less durable.

Acceleration

- _________________________ is produced by the CO_2 gas cylinder.

- The CO_2 canister produces thrust when you _____________________ it – propelling the CO_2 car forward

- It works similar to sticking a pin in a __________________- The balloon is propelled around the room by the thrust created by the escaping gas.

Forces of Resistance

- ____________ (from air resistance)
- Friction
  - -keep the axles free to rotate
  - Stop the wheels from rubbing the car body

Drag

- Take a piece of wood, slap wheels on it, and shoot it down a track at 100 km/h and the air rushing over the body and the wheels will to _______________ it down.
- Scientifically this is called drag: The _________________ of wind moving over an object.
- You want a smooth flow of air free of swirling currents called eddies!

Minimizing DRAG

The Balancing Act:

– Advantages:

________________________________ shaped cars have less drag so they go faster.

– Disadvantages:

Aerodynamically "clean" cars are more _____________________ to build.

Friction

Friction is a product of ________________________

- On a CO2 car,

friction occurs primarily in ______________ places:

– between the ___________________ and the ground,

– between the __________________ and the car body,

– between the eye-hook and the _____________ line track.

Minimizing Friction

- Make sure the axle & tires are ___________ rotate.
- Make sure the wheels are not __________________ on the car body.
- Be sure to install your ______________________ properly. Poorly aligned eye-hooks often the cause of a slow car.

What's the best design for a CO2 car?

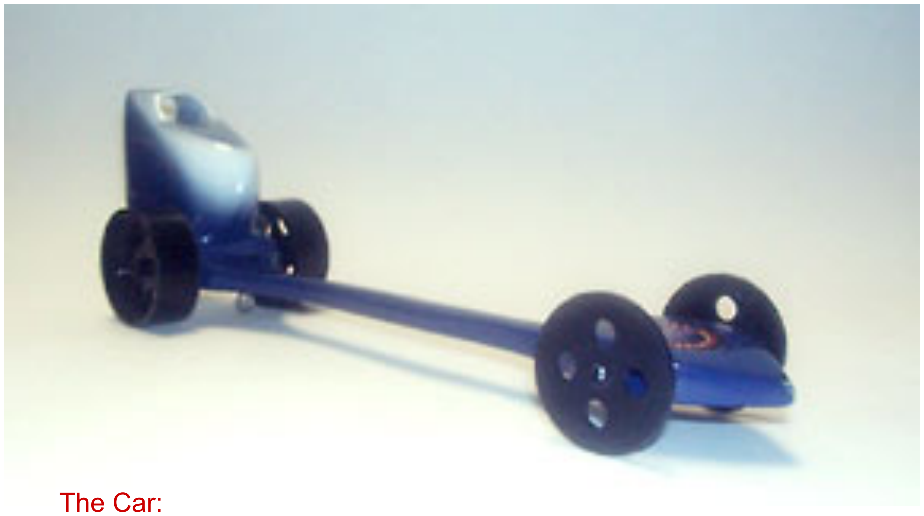
- Your Car must meet the _____________ and dimensional requirements of TSA.
- The best design is the one that ________________. There is no "one design" that is best.
- Generally, the two best indicators of a good car are clean aerodynamics and high _________________________________. Often, really good designs that are built poorly will loose to so-so designs built well.

Types of CO2 Cars

- CO2 cars come in all shapes and sizes and no two cars are ever the same. There are however five basic types of CO2 cars.

• Rail Cars • Shell Cars • Show Cars	• Transportation Modeling • Normal

Rail Cars



The Car:
The Blue Streak by Mr. John Vice, McNabb Middle School, Mount Sterling, KY.

Rail Cars
Rail cars seem to be the most common, especially at the lower grade levels where cars are most often made by hand. These cars can use stock axles and wheels easily, and can be made with most typical wood working tools.

General Characteristics:
- A narrow "rail" that connects the front axle to the back of the car.
- Typically use external wheels (wheels on the outside of the body).
- The body of the car is usually lower to the ground in the front and middle and then rises up abruptly to hold the CO2 cartridge.

- Pros:
  - Easiest to build and design.
  - Thin rails reduce weight of the car, increasing speed.
  - Can be built with normal wood working tools by most students.
- Cons:
  - The thinner the rail, the greater chance of structural failure (breaking).
  - Exterior wheels are bad for aerodynamics.
  - Body shape tends to encourage drag and hamper good aerodynamics.

Shell Cars

The Car:
The Black Widow by Mr. John Vice, McNabb Middle School, Mount Sterling, KY.

Shell Cars
Shell cars are a very special breed. These cars are built for one thing only: speed. Most national and state champions use shell car designs. Most often they are made with a CNC and CAD programs, but can be made with hand tools.

General Characteristics:
- Internal wheels.
- Clean aerodynamic "bullet' shape.
- Hollow underside forming a thin "shell" body.

- Pros:
  - Very low drag aerodynamic shape.
  - Usually capable of high speeds by design.
  - The highest use of technology when designed on CAD and created with a CNC.
- Cons:
  - Requires special wheels, axles and attachment clips - all non-stock parts that will add cost.
  - More difficult to build, especially by hand; may be beyond the skill level of students.
  - Shell cars tend to all look similar reducing individual creative expression.
  - Often requires special tools such as a CNC lathe and CAD program.

Show Cars

The Car:
The Red Rocket by Meaghan M., Webb City Junior High, Webb City, Missouri.

Show Cars
The first thing that comes to mind when one sees a good show car is "Wow!" These cars are often spectacular to look at, and very often never experience a race. Built for showing, not racing, show cars are works of art that display the creativity of their builders.

General Characteristics:
- Stunning design.
- High degree of creativity in the design.
- Usually very intricate and delicate in their construction.
- Very showy paint jobs with glass like finishes.

- Pros:
  - Just plain cool to look at.
  - An excellent way to develop visualization, design, and manufacturing skills.
- Cons:
  - Normally not made for racing.
  - Showy designs often flaunt structural weaknesses making them fragile.
  - Often uses special chrome parts, such as rims, that are an added expense.
  - Usually requires special tools such as a rotary sanding tool to create intricate details.
  - May be beyond the skill level of many students.

Transportation Modeling Cars

The Car:
The 57' Chevy by Mr. John Vice, McNabb Middle School, Mount Sterling, KY.

Transportation Modeling Cars
These cars look like, well, cars. Modeled after some type of real automobile or truck, TM cars are similar to show cars in that they often do not race and are built more for looks than speed. In national competitions,the theme for the subject from year to year will change, ranging from cars to ambulances to even school busses!

General Characteristics:
- TM cars are recognizable as actual vehicles that one would see in real life.

- Pros:
  - A cool challenge to the design and build skills of their creators.
- Cons:
  - TM cars, by design, often don't race.
  - When raced, due to their size and shape they may not achieve top speeds.
  - Requires a high degree of modeling skill.
  - Requires a higher skill level to build well than other cars.
  - Often uses special chrome parts, such as rims, that are an added expense.

Normal Cars

The Car:
Baby Brother by Mr. Cousineau, Chicago IL.

Normal Cars
Make your own car. Be creative. Design and build a car that has your style written all over it. For example, the car here has a pseudo-rail design using exterior wheels and stock parts. But it also borrows some of its looks from Indy Formula cars like a TM car might. The CO2 area is modeled on the bullet shape of shell cars. Finally the whole car is as nicely designed as it could be made so that it would have some show car qualities, from its tiger shark decals (borrowed from and A-10 model) to the 20+coat glass-like paint job.

General Characteristics:
- Normal cars are built to race.
- Normal cars may use characteristics of other car styles.
- Although the wheels are usually external, Normal Cars sometimes have internal front wheels.

- Pros:
  - Totally reflects the skills, abilities and creativity of the designer/builder.
  - Always gets to race, and often does well at the school level.
  - Can be built by the average student with average ability and normal tools.
  - Doesn't require any special parts or materials.
- Cons:
  - May or may not be competitive on a national level.

CO2 Design

Everyone wants to design a CO2 car that will scream down the track and leave their classmates in the dust, right? Well, designing a CO2 car is like any other design challenge. In order to do well, you have to know what your doing, and this requires some homework.

Before you start whining "why can't he just tell my what to do," remember: It's your car. If you don't care about any of this, then you just won't do very well, giving your classmates the power to crush your car come race day.

Making a super fast car involves learning about the principles behind CO2 cars, the engineering factors involved, and the design restrictions you must work within.

CO2 Engineering

- Most people will refer to CO2 cars as dragsters. This invites the comparison to top fuel dragsters the likes of which are often seen (and heard) screaming down a dragstrip at incredible speeds. And yes it's true that CO2 cars are run two at a time in a race down a track just as those big thunderous top fuel dragsters are. But that's where the comparison ends.

- CO2 powered cars run on the same principle that propels rocket or jet powered land speed record vehicles. One of these vehicles, Thrust SSC of the Thrust SSC Team from England, recently broke the land-speed record as well as the sound barrier (over 760 MPH).

    - The driving principle behind these cars is that of Newton's Third Law: **"For every action, there is an equal and opposite reaction."**

CO2 Engineering

- You see, it works like this: when the CO_2 cartridge is punctured in the starting gate, the CO_2 escapes with a great deal of force towards the rear of the car. And just as good Sir Newton would have predicted, the CO_2 car reacts in the opposite direction with equal force rocketing down the track. Unlike a dragster engine that converts fuel into energy to drive a set of wheels, our CO_2 race car is basically pushed by the CO_2 cartridge.

- Many of the features of a dragster will actually work against a CO_2 race car. For example, spoilers are used to force a dragster's wheels into the ground in an effort to increase traction so that all the engine's energy can be transformed into forward motion.

- Thanks to Newton's Third Law, the CO_2 cartridge pushing our cars takes care of forward motion for us; spoilers, although cool looking, just add drag. Dragster engines burn enormous amounts of fuel which requires large air intakes and exhaust pipes to suck air into the engine and shoot hot exhaust gasses out of the engine. Our CO_2 race cars have no engine and burn no fuel, so air intakes and exhaust pipes only act like parachutes to slow them down.

CO2 Engineering

- **Moral of the story:**
When one looks at the similarities between a CO2 race car and a land speed record vehicle (LSRVs), then throw in knowledge of Newton's Third Law, it becomes clear that designs for CO2 race cars should be styled after LSRVs, and NOT dragsters

CO2 Engineering

- Engineering is like a balancing act. When you do one thing to overcome a problem, often you create another two problems, never solving either entirely. It's a game of give and take. And in CO_2 design, it is no different. Engineering a CO_2 car can be broken into four main principles.

CO2 Engineering

- **Engineering Principle No. 1: Mass**
  CO2 cars are a great deal lighter than barbells, but they still have weight; what scientifically we call Mass. It should be obvious that it takes less force to push 40 grams than it does to push 130. So why on earth would someone want to choose make a 130 gram car?

- Because it's much stronger. That's why. If a car is designed to be hollow, or have a narrow body, a lighter car,may destroy itself during a race. If a car is in three pieces, it generally doesn't run very well.

The Balancing Act:

- Advantages:
  Cars with less mass go much faster.
- Disadvantages:
  Cars with less mass are less stable and less durable.

CO2 Engineering

- **Engineering Principle No. 2: Drag**
  Take a piece of balsa wood, slap wheels on it, shoot it down a track at 60 MPH and the air rushing over the body and wheels will try to slow it down. So how do you overcome drag? Start by making the body as aerodynamically "clean" as possible.
- Think of vehicles designed for high speed such as rockets and jet fighters and go from there. But don't forget the other parts of the car. Lola Cars, who made Indie style race car bodies, attribute as much as 50% of a car's drag to the wheels. So it's a good thing to try to get them out of the air stream as much as possible. But again, to do this will require more time and skill than just an ordinary car.

The Balancing Act:

- Advantages:
  Aerodynamically shaped cars are less "draggy," so they go faster.
- Disadvantages:
  Aerodynamically "clean" cars are more difficult to build.

Lola Cars MK6 GT

CO2 Engineering

- **Engineering Principle No. 3: Friction**
  Thanks to our friend gravity, everything has friction. On a CO2 car, friction occurs primarily in three places: between the wheels and the ground, between the axles and the car body, and between the eye-hook and the fish line track. So how do you eliminate friction? You can't. You can only reduce friction.

- First, make sure the tires are free from any defects by carefully sanding or cutting them away. Make sure they are not rubbing on the car body! Next, add a straw that acts as a wheel bearing. Next, sand away any imperfections on the axles. Finally, be sure to install your eye-hooks properly. Poorly aligned eye-hooks are often the cause of a slow car.

The Balancing Act:

Advantages:

- A friction filled car is easy to build.
- A friction filled car is slow, so it tends to be more durable.

Disadvantages:

- Reducing friction takes a lot of extra effort, time and patience.

CO2 Engineering

- **Engineering Principle No. 4: A Design Envelope**
  In the real world most everything has a limit. That limit could be technology available, labor available, materials, or cost. For example, oil tankers are designed to be just wide enough that they will fit through the Panama Canal. Our CO2 cars also have a set of minimum and maximum dimensions, called Design Restrictions.

- Many students will automatically assume that if they make their car to the minimum specifications that it will be faster. Other students will keep their car at maximum length in hopes of having an advantage. Who's right? One thing is sure: if your car doesn't meet the minimum or maximum dimensions, it won't be racing at all. Without Design Restrictions the competition would not be fair.

- The Balancing Act:
  Advantages:
  Cars that follow design restrictions can compete equally and safely.

- Disadvantages:
  Cars may go faster if design restrictions are not followed, but will be disqualified.

Design Restrictions

<u>**Body**</u> **Minimum length**: 11” **Height:** 3.5” max, 2 ¼” minimum **Width at Axles:** 1 ¼ minimum **Width all other**: 1 5/8 max, ½” minimum	<u>**Safety**</u> Power plant housing thickness 1/8” minimum Screw Eye separation 10 ½” maximum, 7” minimum
<u>**Axles**</u> Diameter 1/8” Wheel Base: 10” max, 7” min Distance from bottom of car: 1/4-3/8” Distance from end of body: 1” max, ½” min	<u>**Notes:**</u> Body height is measured at the rear axle, including wheels If your car does not meet <u>**ALL**</u> Design Restrictions it will not race

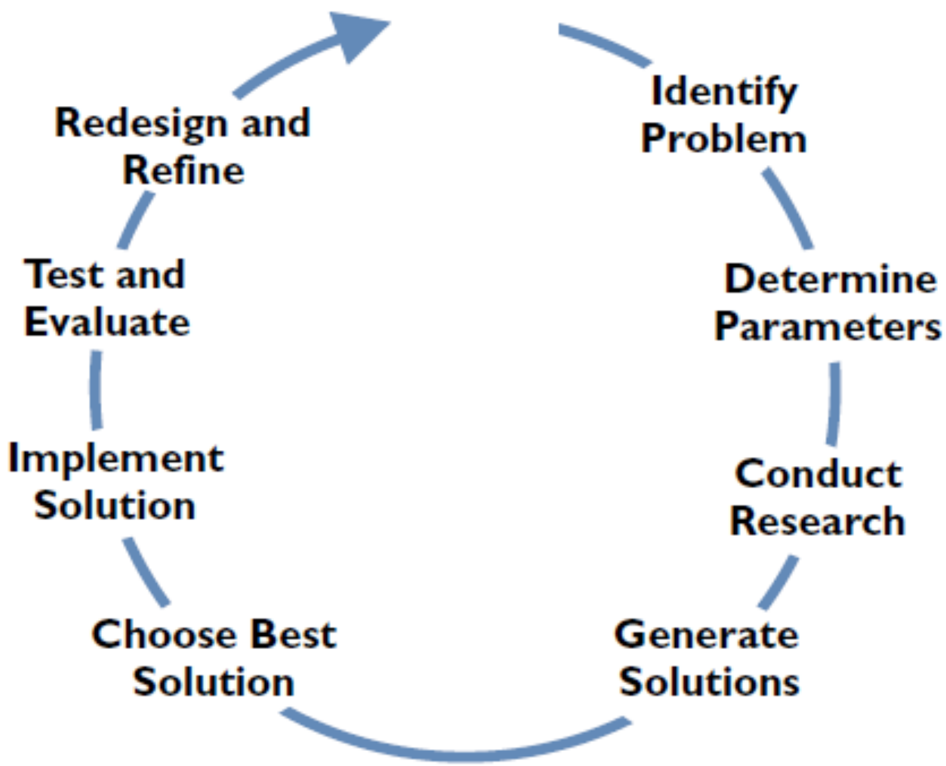
Quick Clip!

- “A Faster Horse” documentary about the production of the 2015 Mustang
- https://youtu.be/Um4XsH5ymiw

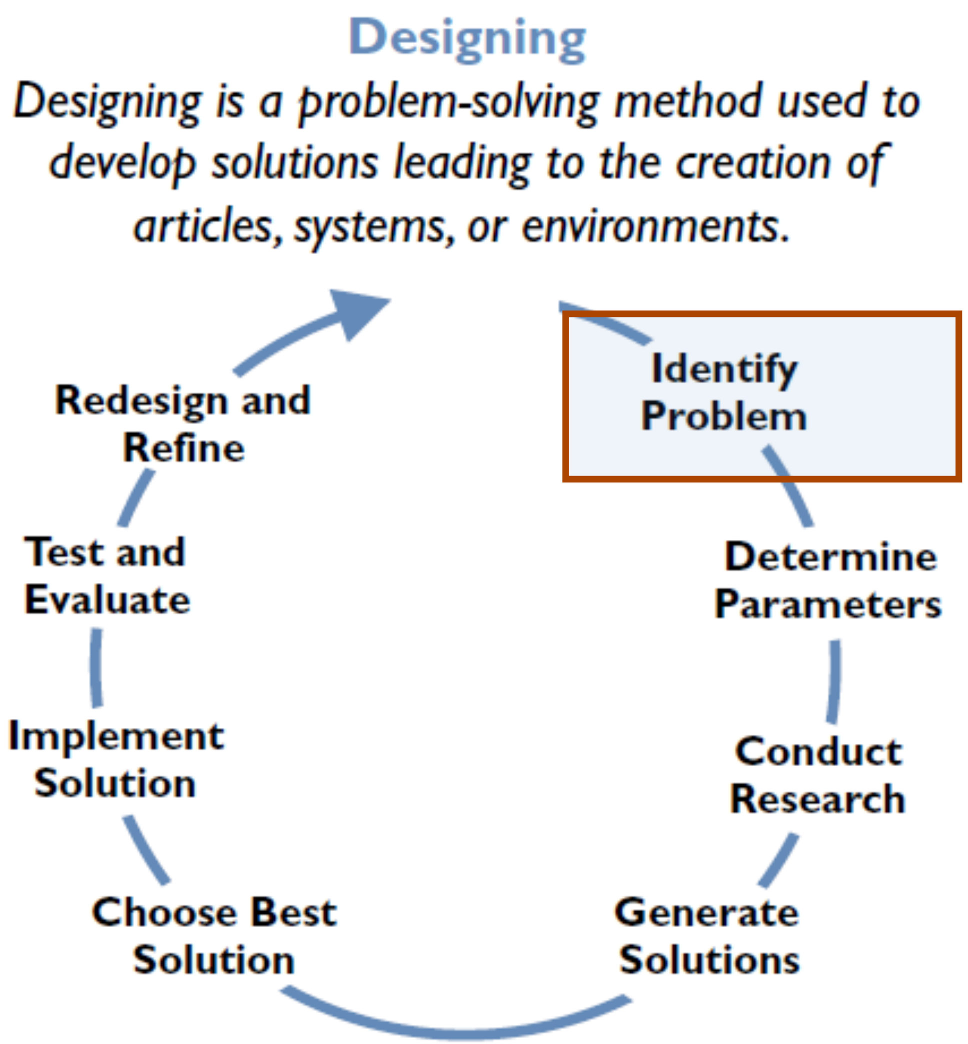
Design Matrix (Cyclical)

Designing

Designing is a problem-solving method used to develop solutions leading to the creation of articles, systems, or environments.

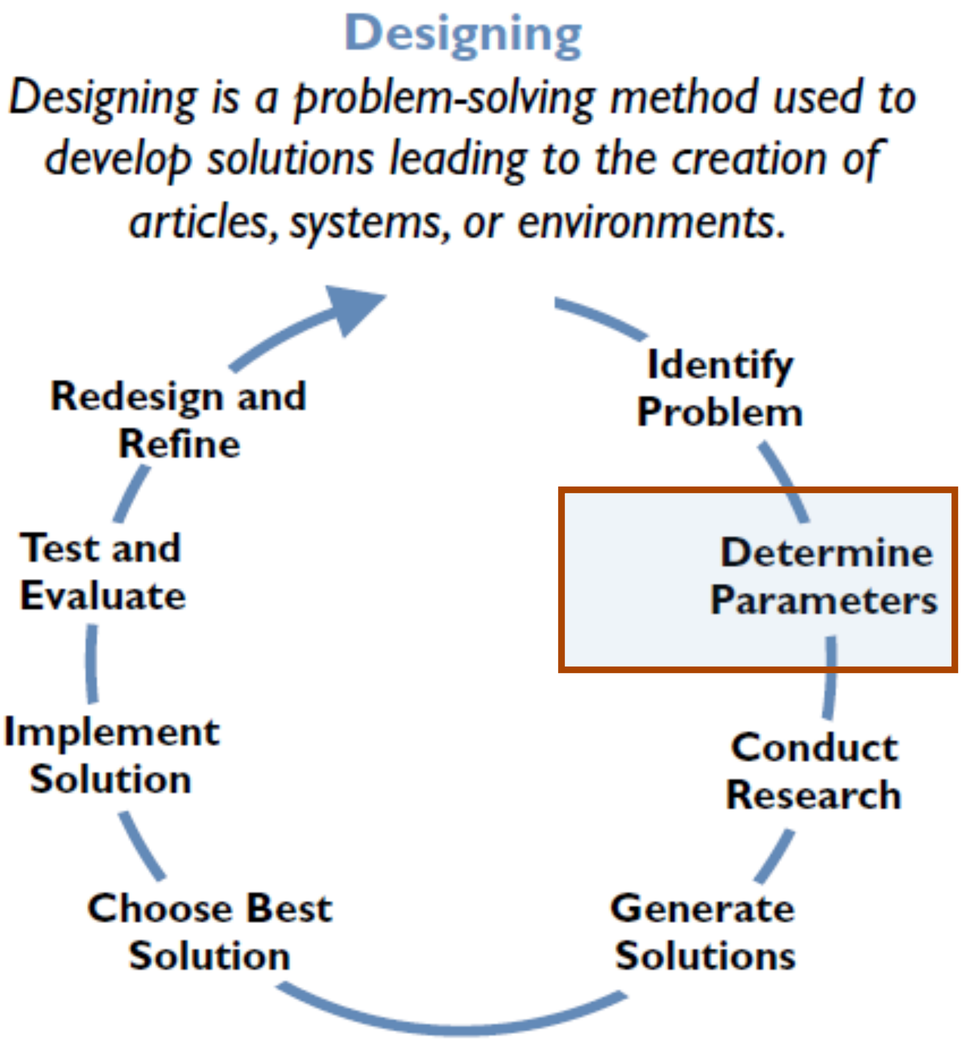


Design Matrix (Cyclical)



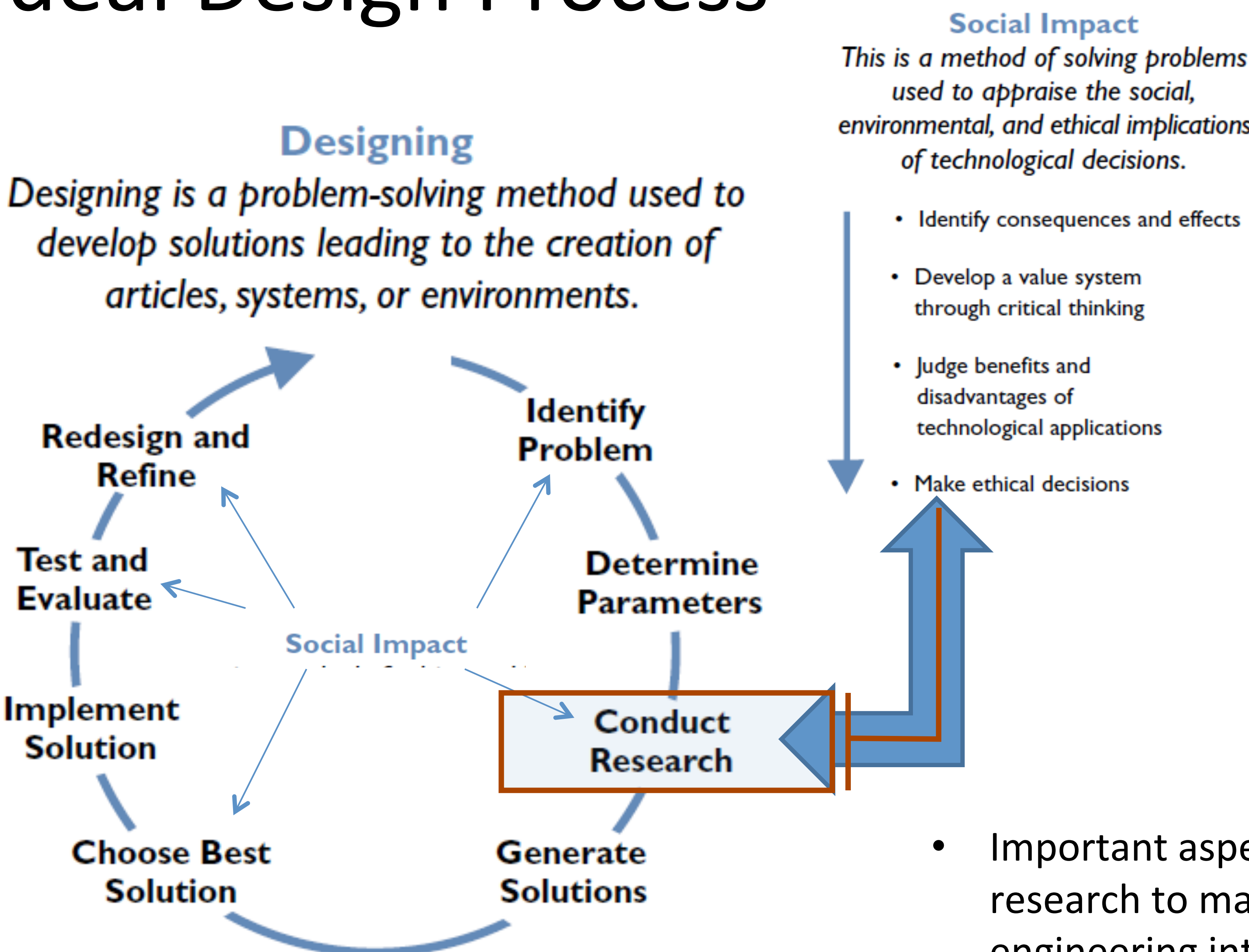
What are we building and why?

Design Matrix (Cyclical)



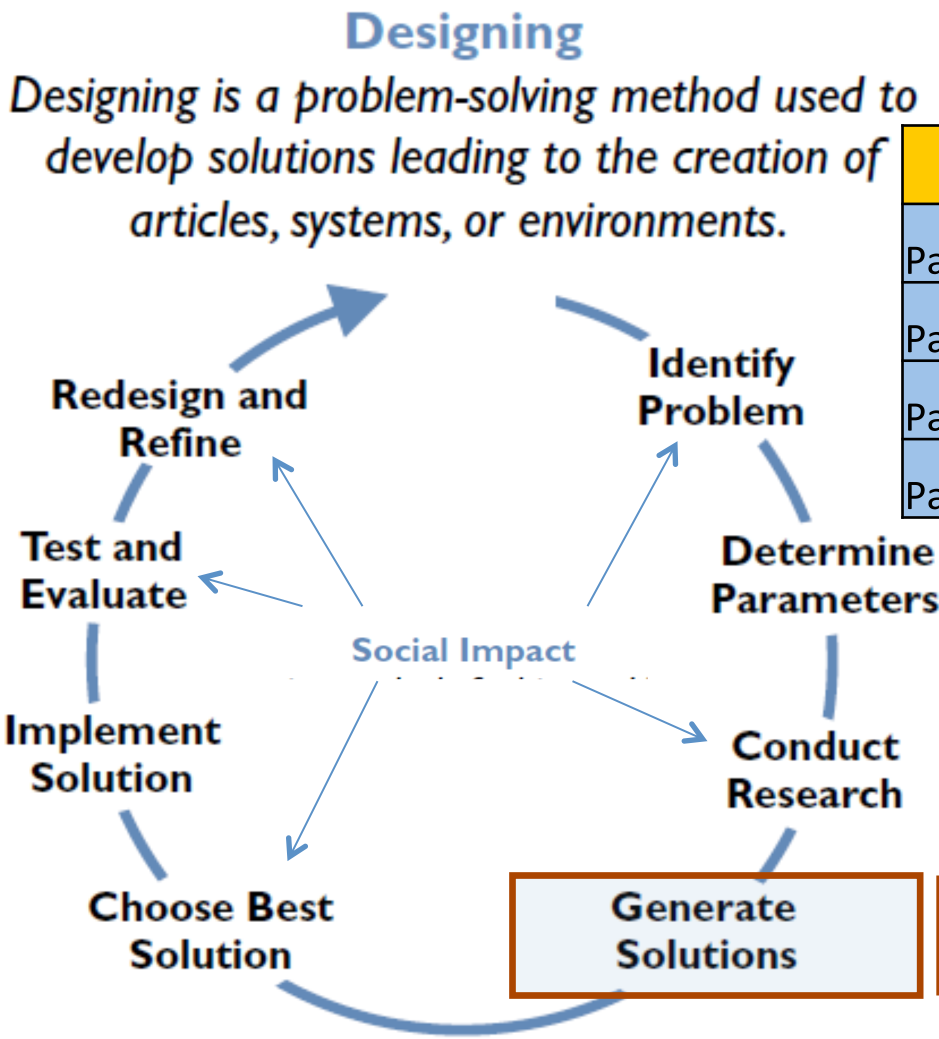
What are the parameters for this project?

Ideal Design Process



- Important aspect of research to maintain engineering integrity.

Ideal Design Process



	Solution 1	Solution 2	Solution 3
Parameter 1	**1**	**2**	**3**
Parameter 2	**3**	**1**	**2**
Parameter 3	**2**	**1**	**3**
Parameter 4	**3**	**2**	**1**

Use a **Design Matrix** to find the Best Solution.

Design Matrix Example

- Rank the solutions in order of how effectively they speak to the parameters.
- Choose solution that solves/answers the most parameters in the best way.

	Solution 1	Solution 2	Solution 3
(x2) Parameter 1	**7**	**10**	**9**
Parameter 2	**10**	**9**	**7**
Parameter 3	**9**	**8**	**4**
Parameter 4	**6**	**5**	**2**

Solution 2 seems to achieve the highest rank.

Design Matrix Example

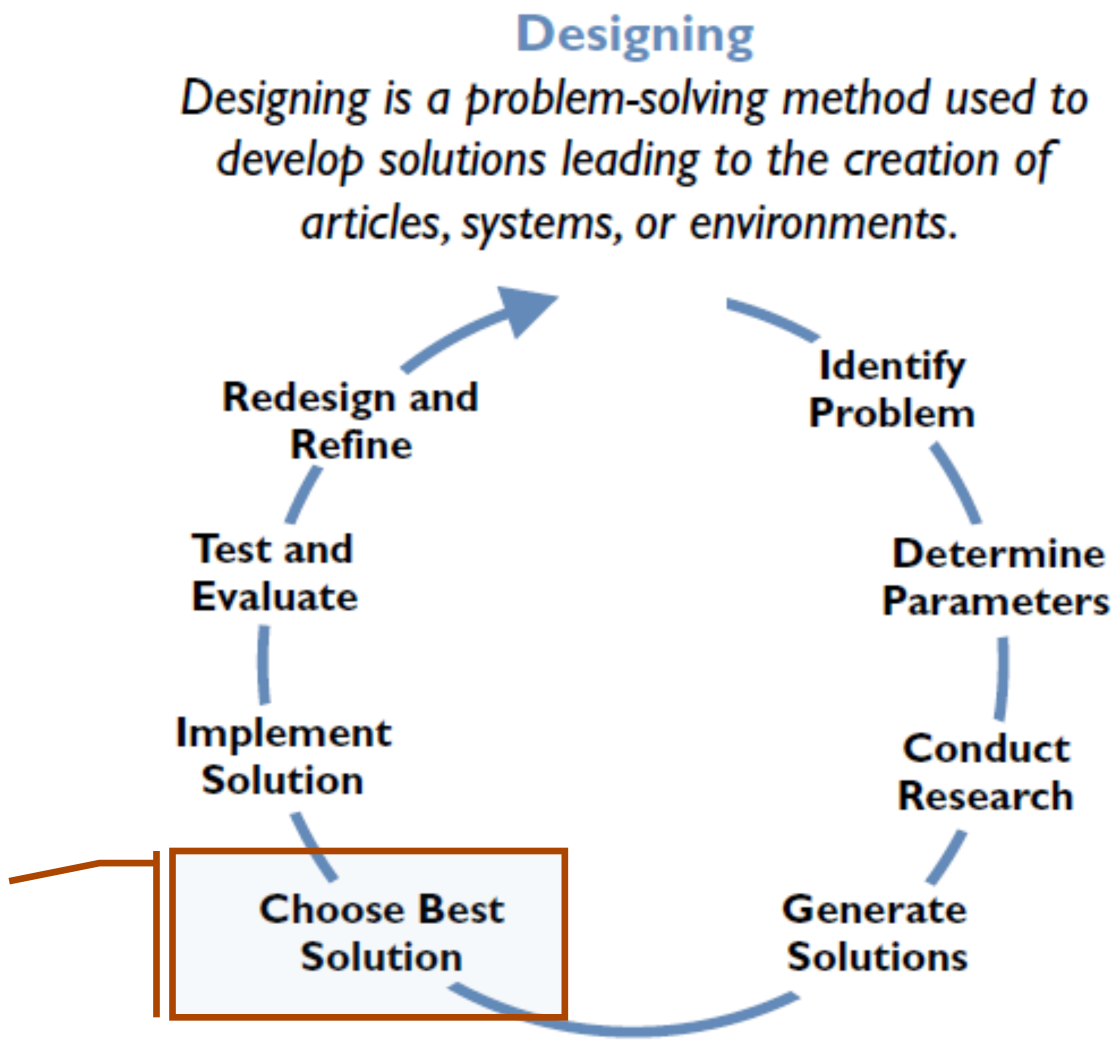
	Solution 1	Solution 2	Solution 3
(x2) Parameter 1	**7**	**10**	**9**
Parameter 2	**10**	**9**	**7**
Parameter 3	**9**	**8**	**4**
Parameter 4	**6**	**5**	**2**

39 – 42 – 31

- Simple numerical value to decide best solution.

Design Process (Cyclical)

SOLUTION 2

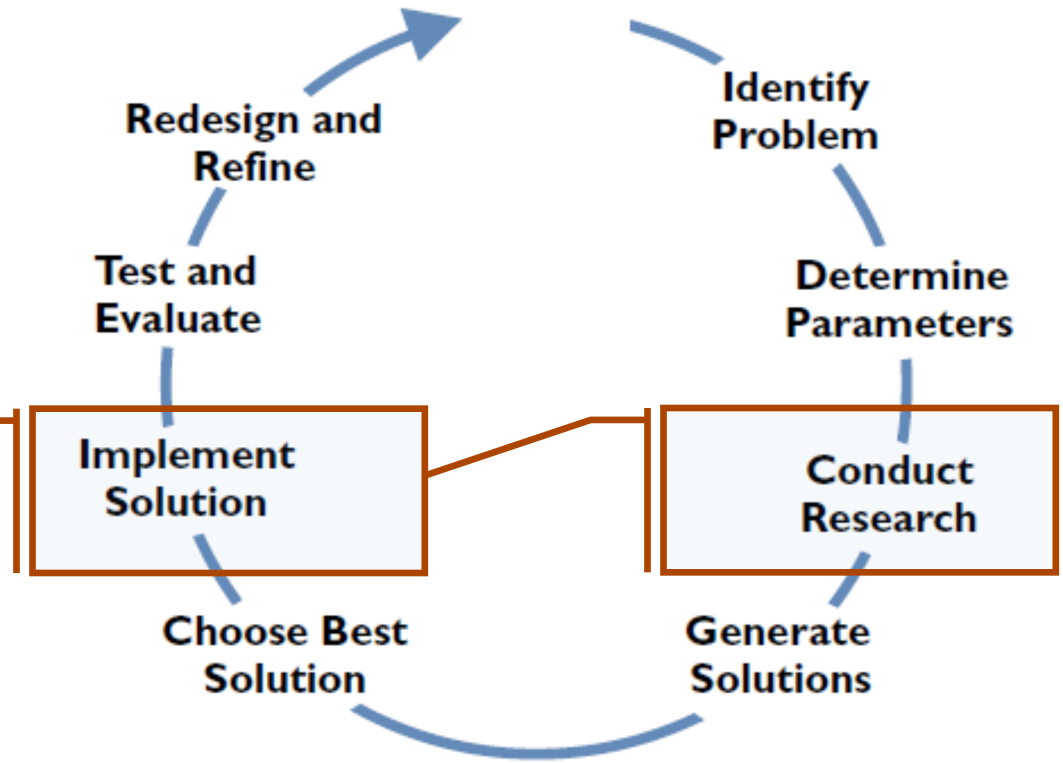


Design Process (Cyclical)

Designing

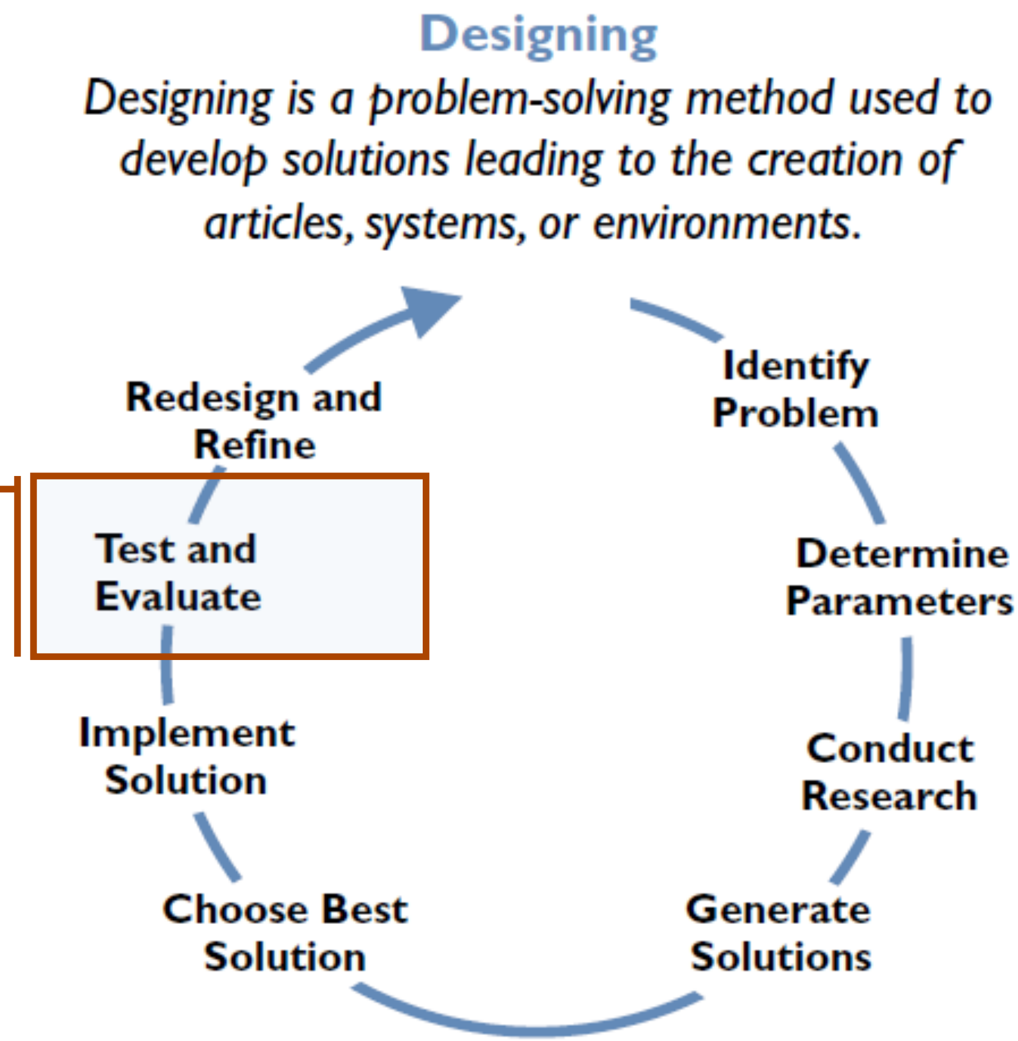
Designing is a problem-solving method used to develop solutions leading to the creation of articles, systems, or environments.

Working Drawing, Production Plan, Prototype & Build.



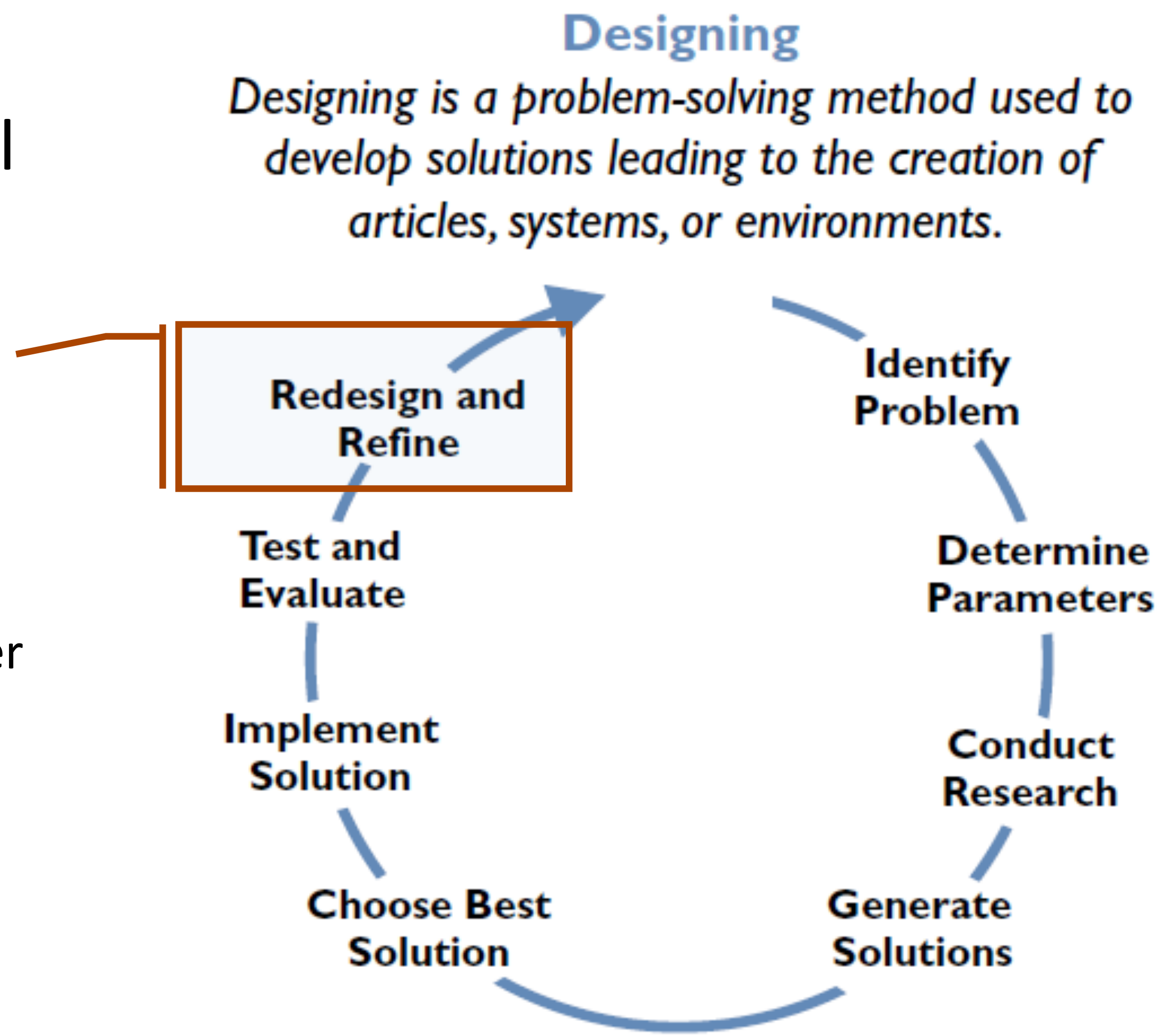
Design Process (Cyclical)

- We will have to make minor changes to our projects during the test and evaluation period.



Design Matrix (Cyclical)

- Often times we will close a project following the test and evaluation period.
- Although it is likely at this point you will have a better idea of how you can improve your project.



5 step design

1	2	3	4	5
Thumbnails	Rough Sketch	Final Drawing	Prototype	Production

- Production
- When producing the final dragster, good craftsmanship is very important. Your dragster will perform it's best if you build it very carefully

- So why all this planning?
- In engineering poor planning can lead to disaster. Bridges falling apart, buildings collapsing, cars exploding and crashing!
- Problems always occur but we do our best with planning to prevent things from happening

- A real car has over 4000 working parts. Ours will probably have less than 10. All the parts serve a specific purpose and function. Each part will have its limitations and reasons for being used