



# Biomedical Engineering and The Robotic Engineering Design Process Used in Project Warp Speed

By 1715G, Gigabytes From  
Hopkinton, MA, USA

Evan Mathur, Suren Sahakyan, Divit Vallandas, and Ian Pararas





# TABLE OF CONTENTS

01

## Why We Chose This

Why did we choose Biomedical Engineering as our STEM career

02

## Engineering Design Process

What is the Engineering Design Process, and how does it relate to Bioengineers?

03

## Identifying Problems

How do we identify problems in robotics, and how does it connect to Project Warp Speed?

04

## Brainstorming Solutions

How do we use brainstorming in robotics? How does this apply to Covid 19?

05

## Creating a Solution

How do we create and design successful solutions in robotics

06

## Testing Our Solution

How do we use testing to improve upon our ideas, and create optimal solutions?



# 01



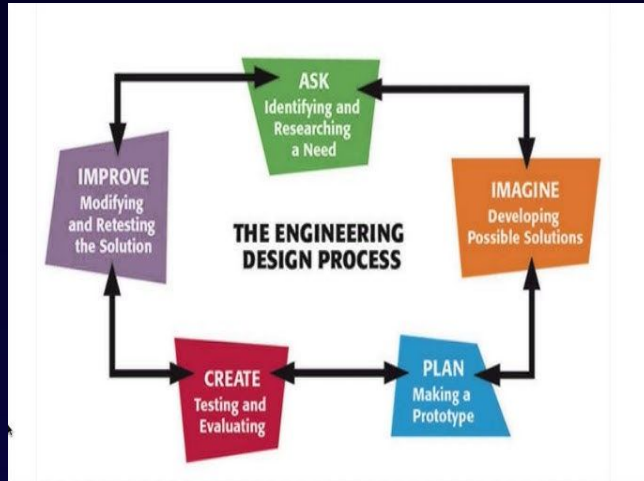
## Why We Chose This

After researching the vast field of STEM careers and the impact of robotics on these careers, our team has decided to focus on Biomedical Engineering. We will highlight similarities between the world of vex and bioengineering. We have chosen bioengineering since people on our team share many different interests. We have people who would like to be engineers, doctors, teachers, and even pursue business in the future. Bioengineering applies to robotics because, in robotics, we need to create a sustainable, usable, and prosperous bot. Bioengineers are given the task of applying engineering concepts to medicine. We have decided to conduct our research on Pfizer and Project Lightspeed, the race against time for a vaccine.



# 02

## Engineering Design Process



Bioengineers have to identify problems in their area, and find ways to fix them. They must combine the Engineering Design Process with the principles of science. They are tasked with asking questions to find out about a phenomenon, and then engineering a design which can solve these problems. This presentation will detail how these engineers have to use the engineering design process, and the ways they have applied it in the Pfizer Covid-19 Vaccine.

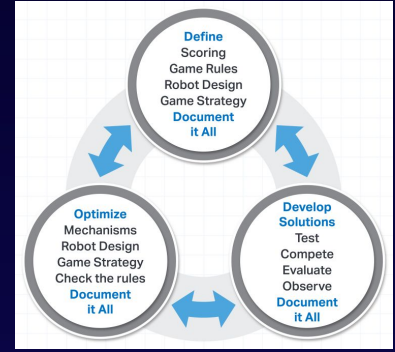
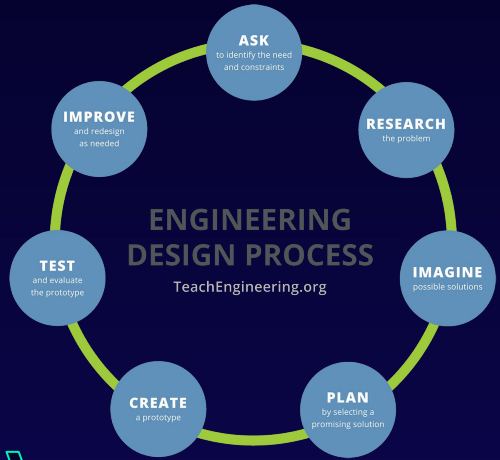




# 03

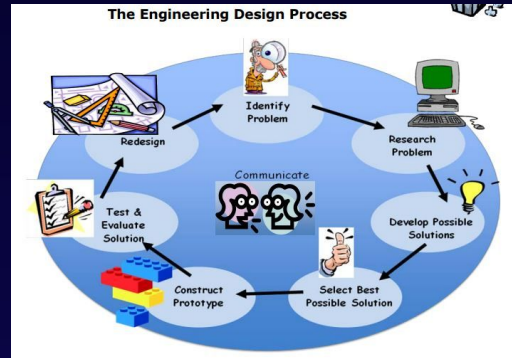
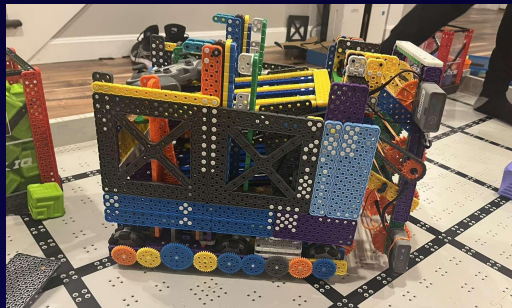
## How We Use The Engineering Design Process

We apply the Engineering Design Process in VEX robotics, starting with defining objectives. Competitions serve as testing grounds, allowing us to enjoy the challenges and refine our designs for continuous improvement.



# Applications

In March 2020, as COVID-19 spread globally, Pfizer applied the engineering design process in Project Warp Speed, a joint government and Pfizer initiative. The challenge was to create a vaccine within ten months. This endeavor, completed by the end of 2021, aimed to solve the pandemic that had confined people to their homes. Similar to Pfizer's impact, VEX students also have the potential to change the world through innovative solutions. These students can use the creativity they harness in VEX to do anything they dream of.



Pfizer-BioNTech COVID-19 Vaccine

## What's in a COVID-19 Vaccine?

Manufacturer and Name: Pfizer-BioNTech  
Type of vaccine: mRNA

Scientists have studied how to use mRNA to protect us from viruses for a long time. They used that knowledge to make COVID-19 vaccines using mRNA that are as safe and effective as possible. Learn more about what is—and isn't—part of these COVID-19 vaccines.

Each ingredient in this vaccine has a specific job.

1

mRNA, or messenger RNA

mRNA is genetic material naturally found in the body. It teaches the body's cells how to make proteins. The modified mRNA in this vaccine teaches your body how to make a protein usually found on the surface of the virus that causes COVID-19. Whenever your body sees that protein, it starts making antibodies. Those antibodies then stand ready to seek and destroy the virus if it shows up later. mRNA is the active ingredient in this vaccine, meaning it's what helps protect you from COVID-19.

2

Lipids, which are fatty, oil-like particles.

Lipids\* form a protective layer around the mRNA to keep it safe on its journey to the cells.

3

A saline (salt-based) solution called phosphate buffer solution (PBS).

The buffer solution keeps all the vaccine ingredients exactly the same from the time they are made and shipped until they are given to people. It is made with salt compounds\*\* and sucrose (sugar).

What isn't in it?

The vaccine's mRNA can't change your DNA. There is no live or whole SARS-CoV-2 virus in this vaccine, so you can't get COVID-19 from it. Eggs, preservatives, fetal cells or any other kind of cell, mercury, and latex are also not part of any mRNA vaccines or their packaging.

\* Full chemical names of lipids in this vaccine: (S)-methylphosphatidylcholine, 1,3-bis(sn)-phosphatidylglycerol, 1,3-bis(sn)-phosphatidylcholine, 1,3-bis(sn)-phosphatidylethanolamine, and cholesterol.

\*\* Full chemical names of the salt compounds in this vaccine: potassium chloride, potassium phosphate, sodium chloride, and sodium phosphate dibasic.

Sources:  
 CDC. What's in Your Next Ingredients and Vaccine Safety.  
 CDC. Frequently Asked Questions About COVID-19 Vaccines.  
 NIH. National Institutes of Health.  
 covid19community.nih.gov

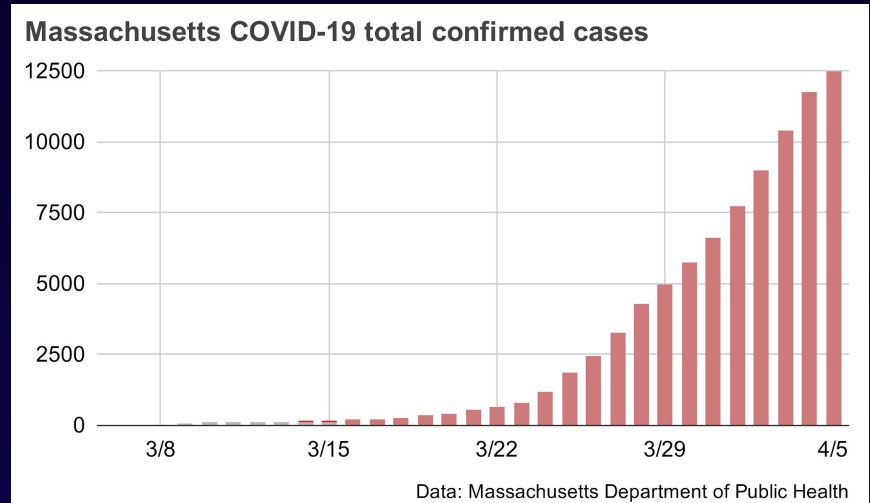




# Identifying the Problem

In March of 2020, citizens of the world went through a frenzy of problems. The reason for these problems was the COVID - 19 pandemic. This pandemic caused 7 million deaths in the world. This pandemic also caused 1.16 million total deaths in the US alone. Once the pandemic was announced, Pfizer and BioNtech began developing the vaccine. These two major tech companies began to create a vaccine in the face of the strongest virus seen in the last 100 years. This problem was immediately identified by health officials across the world.

This chart shows daily deaths rapidly increasing in our state, Massachusetts. One can view the case counts go from a few hundred to 12,500 in less than a month



# Robotics Similarities - Identify Problem

These pages from our notebook illustrate our team's problem-solving, and resourceful approach in the Engineering Design Process. When initially introduced to the game, we prioritize identifying tasks our ideas must address. For instance, to navigate the supply zone, we designed a phase drive for our robot, identifying constraints and requirements promptly. This concept, employed in Project Warp Speed, served as inspiration for healthcare professionals combating the COVID-19 pandemic.



How did Covid - 19 cause a problem?

A page about dumper from our notebook.



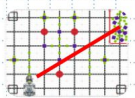
## Identify Problem

### Phase Drive

**Goal** We will identify an objective for our robot so that we can address it and build an effective phase drive through the bar.

**Problem Statement**

We need a mechanism to move around the field so that we can interact with the game objects.



**Solution Requirements**

- ★ Must only use legal VEX Robotics Competition parts
- ★ Must fit within 11" x 15" x 20" cube.
- ★ Must work using no motors

**Solution Goals:**

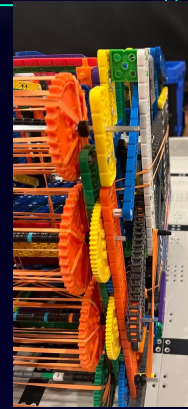
- ★ Drive most of the bot through the bar, at least 70% of bot should clear bar.
- ★ Travel through the bar using no motors.

Project Identify problem  
Name: Evan Mathur Date: 8/17/2023 Page: 59



# Brainstorming Solutions

During the COVID-19 pandemic, Pfizer innovatively developed the mRNA vaccine using AR cameras, skilled engineers, and remote facilities. Similarly, in robotics, resource constraints led us to use a compound gear ratio for our intake due to a chain scarcity, overcoming it with 1x8 beams, rubber bands, and CADs. Efficiency matters in our robot design, such as opting for a roller-based intake system over a slower claw. Pfizer applied a similar mindset, emphasizing speed and quality in creating their highly effective vaccine within a tight



Cad Plan

We have detailed a CAD plan below on how we will build our robot. This CAD is for our initial robot prototype. We plan to have a two wheel drivetrain, an intake, and 2x12s to make the bot stable. **This shows our implementation**

Isometric View

Front View

Right - Side view

Project: Build solution  
Name: Evan Mathur Date: 08/8/2023 Page: 50

### Select And Plan

Drivetrain

Goal: Our goal is to show how we will include the engineering design process in integrating the new drivetrain into our robot plan. We will use CADs

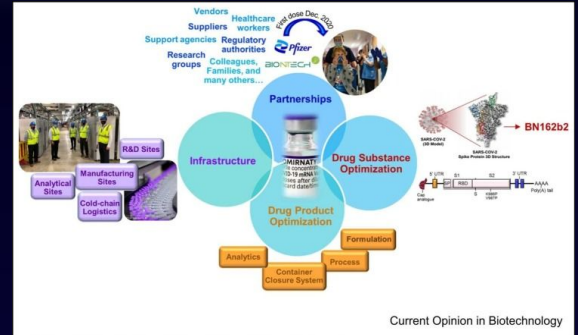
Phase Drive Gap Gear, and wheel 2:1 Drivetrain

CAD Plan

Project: Select and Plan  
Name: Evan Date: 1/2/24 Page: 239

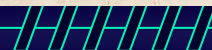
# Building and Creating Our Solutions

Pfizer and BioNTech's engineers and scientists faced the challenge of creating a vaccine, contributing significantly to global health. The vaccine utilizes a lipid nanoparticle containing messenger RNA to trigger antibody production. In VEX robotics, we apply similar problem-solving by using our given resources to build intricate mechanisms, employing fundamental engineering mechanics, such as harnessing potential and kinetic energy in our dumper for efficient cube deployment.



Current Opinion in Biotechnology

We use slope to find the optimal dumper slope. Our current slope is  $y=23/60 x+41/2$ . This helps us to learn more about slope, and math principles.



# Testing Solutions

In robotics, testing solutions is a crucial step, achieved through competitive testing. Pfizer used a similar approach, initially developed a vaccine but identified suboptimal efficiency through numerous tests. By using a phased strategy, they innovated quickly to create an effective vaccine.

### UNDERSTANDING mRNA VACCINES

To build an mRNA vaccine, scientists only need access to the genetic sequence of SARS-CoV-2, and not the actual virus.

**APRIL 2020**

**Spike proteins**

Our scientists have focused on the genetic sequence for the virus's "spike" protein, which can then be used to synthesize an mRNA sequence, instructions that the cell can use to make the "spike" protein.

**mRNA LNP** **Cell**

**ANTIBODIES**

The synthetic mRNA is then packaged in a lipid nanoparticle (LNP) that serves as a "delivery vehicle" shuttling the instructions to our cells.

Once inside the cells, the cellular machinery follows the mRNA instructions to produce the viral protein, which is then displayed on the surface of the cell and stimulates the immune system to mount a response.

BioNTech and Pfizer have begun testing four versions of mRNA vaccines in humans to determine whether it is safe and effective and the immune response is sufficient.

### Testing Solutions

Intake Rebuild

**Goal** We will test our intake by intaking the whole field with our robot in 40 seconds.

**Test Procedure:**  
There will be 3 tests:

1. Pick Up the whole field cubes in 40 seconds
2. We will put 20 cubes through the intake in batches of 3 for green and 1 for purple, if any problems occur it will be a failure (jamming, glitching, stopping, skipping gear, breaking)
3. Can the intake process green cubes in 2 seconds and a purple within 3 seconds

Test	Whole Field Pick up test	Malfunction test	Time Test
Pass OR Fail	Pass - the robot successfully cleared the field with a 5 second stop time. This is a testament to our fast intake and swift drivetrain	Pass - all cubes successfully passed with one cube almost getting stuck, this cube didn't take long to go up, and almost got stuck in a rubber band	Fail - one cube took 4 seconds to go into the purple cube layer, this was due to the cube hitting the red 1x10 beam on the dumper

Project: Testing Solutions  
Name: Suren Date: 1/10/24 Page: 258

### WHAT ARE THE STEPS TO DEVELOPING A VACCINE?

**STEP 01 RESEARCH**

**STEP 02 PRECLINICAL**

**STEP 03 CLINICAL**

**STEP 04 REGULATORY**

**STEP 05 PRODUCTION**

**STEP 06 QUALITY CONTROL**



Sources:

[Pfizer Direct Article](#)

[Pfizer Article](#)

[Washington Post](#)

[CNN Article On mRNA Vaccine](#)

[Pfizer and BioNtech testing](#)

[How Are Vaccines Developed? by Pfizer](#)

[The People Behind Your Vaccine](#)

[CDC Article](#)

[Vaccine Technology](#)



## Our Team (referenced from our notebook)

**First Meeting**

1715G Team Biography

We are team 1715G Gigabytes from Hopkinton Middle School, Hopkinton, Massachusetts. Our Student-centered and hands-on team strives for excellence in everything we do. Together we have 2 years of participation in the VEX Robotics Competition program. We are excited to learn new skills and apply those new skills in this season. VEX Robotics Competition "VIQRC" Full Volume



Suren Sahakyan

I am Suren, I am in 8th grade, and I take part in coding, building, and notebooking for our robotics team. I am our Team Captain, and my strengths are problem solving, and building creative designs.



Divit Vallandas

I am Divit, an 8th grader in my second year on the team, and third year in robotics. I am a driver, builder, and online challenger for our team. My strengths are driving, strategy, building, and writing. I am excited to achieve our goals during this VEX IQ season.


**Mission Statement**

Throughout Challenges and Successes we will always innovate and improve.

Project: 1715G Team Biography  
Name: Evan Mathur Date: 05/24/2023 Page 5


**First Meeting**

Team Intros



Evan Mathur

I am Evan Mathur, I am in my second year of robotics, and first year on the team. I am a coder, notebook manager, online challenge leader and builder for the team. My strengths are writing, building, communication, gaming strategy and math. I hope that our team can achieve and surpass our goals this year.



Ian Pararas

I am Ian, in my first year of robotics I am a coder, and a builder. My strengths are coding, and building. I hope to help our team go far during this season.

Project: 1715G Team Biography  
Name: Suren Sahakyan Date: 05/25/2023 Page 6

Word Count: 970