

**DEPARTMENT OF COMPUTER SCIENCE AND SOFTWARE ENGINEERING**  
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**DELIVERABLE 1**

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# Scientific Calculator

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# 1 Introduction

A transcendental number [3] is a real (or complex) number which is not an algebraic number. In other words, it can never solve a non-zero algebraic equation. (For example, if  $x$  is a non-unit algebraic number ( $x^2 \neq x$ , which is similar to  $x \neq 0 \neq 1$ ) and  $y$  is another algebraic number but irrational number. then  $x^y$  is transcendental number). Few examples of transcendental numbers are  $\pi$ ,  $e$ ,  $2^{\sqrt{2}}$ , etc.

One more example of the transcendental number is the Gelfond's constant [1] which is  $e^\pi$ . Since the transcendental numbers exhibit the properties of infinite numbers, the value of Gelfond's constant approximated to 10 digits is 23.1406926327

## 1.1 Calculation

To calculate the value of Gelfond's constant, let's take  $k_0 = \frac{1}{\sqrt{2}}$  and  $k_{n+1} = \frac{1-\sqrt{1-k_n^2}}{1+\sqrt{1-k_n^2}}$  where  $n$  is a positive number. The sequence generated when calculating  $(\frac{4}{k_{n+1}})^{2^{-n}}$  rapidly converges to form the Gelfond's constant ( $e^\pi$ ).

## 1.2 Properties

The value of Gelfond's number is not finite. It does not have any visible pattern. The Gelfond's constant is a proof that the number (or series) produced by the algebraic power of two numbers that exhibit transcendence is also exhibits the properties of transcendence. The Gelfond's constant was introduced in order to solve the Hilbert's seventh problem [2]. One unique property of the Gelfond's constant is that the value of the Gelfond's constant is exactly the same as volume of all unit balls (spheres) with even dimensions in Euclidian Space. The arithmetic operations such as (multiplications, power, multiplications in power, etc) with appropriate algebraic numbers on Gelfond's constant produces the almost integer numbers.

## 1.3 Applications

It is useful when calculating the other constants that help figure the almost integer numbers (e.g. Ramanujan's constant,  $e^\pi - \pi$ , etc.). It is useful to calculate the volume of n-unit balls [4] in Euclidean Space. Therefore, it can be used to calculate the region in n-class classification problems where each class has a unit value.

# 2 Interview

## 2.1 Questions

- Which field are you working in physics? Are you working in any specialization?
- How long have you been involved in this field?
- Is it theoretical physics or experimental physics?
- Do you use any specific device to perform complex calculations?

- What features do you think are missing from the device or software you're using?
- Are you familiar with Gelfond's constant?
- Are you using or working with this constant in any way?
- In future, if you come across an application that requires this constant in your equations, would it be good to have it in a software that you're using?
- what kind of interface would you prefer for the software or device you'd like to use for calculations?
- Would you rather prefer a simple design that is specific to you or a more generic system?

## 2.2 Response

I have contacted Shubham Bhagat, a PhD student at Concordia University. We've had a text-based interview session through instant messaging platform. Here are the responses I have gathered from her.

**Q. Which field are you working in physics? Are you working in any specialization?**

A. My topic is related to both chem and physics. Broadly it is organic semiconductors.

**Q. How long have you been involved in this field?**

A. I am completely new to this field. It's been 10 months. Eariler I was working with inorganic semi-conductor.

**Q. Is it theoretical physics or experimental physics?**

A. Experimental

**Q. Do you use any specific device to perform complex calculations?**

A. Not calculation but you can say data processing like which material property we want to explore, then deciding which characterization technique( or simply which instrument) to use and then interpreting the experimental data obtained from that instrument.

**Q. What features do you think are missing from the device or software you're using?**

A. No. Sometimes we don't have access to all that specific technique or its not possible to measure the samples right away. Some of the software are paid. I would like them to be freely available

**Q. Are you familiar with Gelfond's constant?**

A. No

**Q. Are you using or working with this constant in any way?**

A. No

**Q. In future, if you come across an application that requires this constant in your equations, would it be good to have it in a software that you're using?**

A. It would be nice if I can do some noble work and if that require using this constant then I would surely love to have it in my software

**Q. what kind of interface would you prefer for the software or device you'd like to use for calculations?**

A. I would prefer online interface where I can decide which parameters I would need and easily access it from anywhere. Sometimes one thing does not fit all, and also I won't be really sure about the way that instrument would have been programmed to do certain calculations.


**Q. Would you rather prefer a simple design that is specific to you or a more generic system?**

A. A generic one which is easy to modify.

## **2.3 Analysis**






Shubham Bhagat is a PhD student researching organic semiconductors at Concordia University. She is relatively new to this field. It has been 10 months since she has switched from Inorganic Semi Conductor. Since she has been working in experimental physics, she has to collect the readings from several experiments and process the data she has collected. She does not use a calculator but she uses a desktop computer to crunch the data and derive the useful calculations. Even though she is not familiar with the Gelfond's constant, she is open to the possibility of working with Gelfond's constant whenever needed. Being experimental physicist, she is more comfortable with the desktop based interface where she can customize it based on the experiments she performs. Even though she prefers to customize the platform, she voted to have as much generic system as possible.

### 3 Persona



## Shubham Bhagat

PhD Student

-  Gender: Female
-  Age: 21-25 years
-  Location: Montreal, Canada
-  University: Concordia University
-  Email: shubh.279@gmail.com

#### About Me

Shubham Bhagat is an Indian student pursuing her PhD in Physics at Concordia University. She is passionate about her research in physics towards her PhD. She is curious about the technology used behind the equipment she uses to help her research.

#### Business Goals

She is a research student at Concordia University. She aims to work with applications of Chemistry in Physics. She is working in organic semi-conductors. She works with different instruments to take the readings from the experiments and the online interface of the calculator will give her flexibility to ease her experiment process. She opens to correlate the Gelfond's constant in her research, this calculator will speed up her research in such direction.

#### Experience & Skills

She is an experimental physicist. Her primary field of research is organic semi-conductors. It has been 10 months since she has switched her field from inorganic semi-conductors. She works with heavy machinery that helps her collect the data sample from the experiments she performs in her lab.

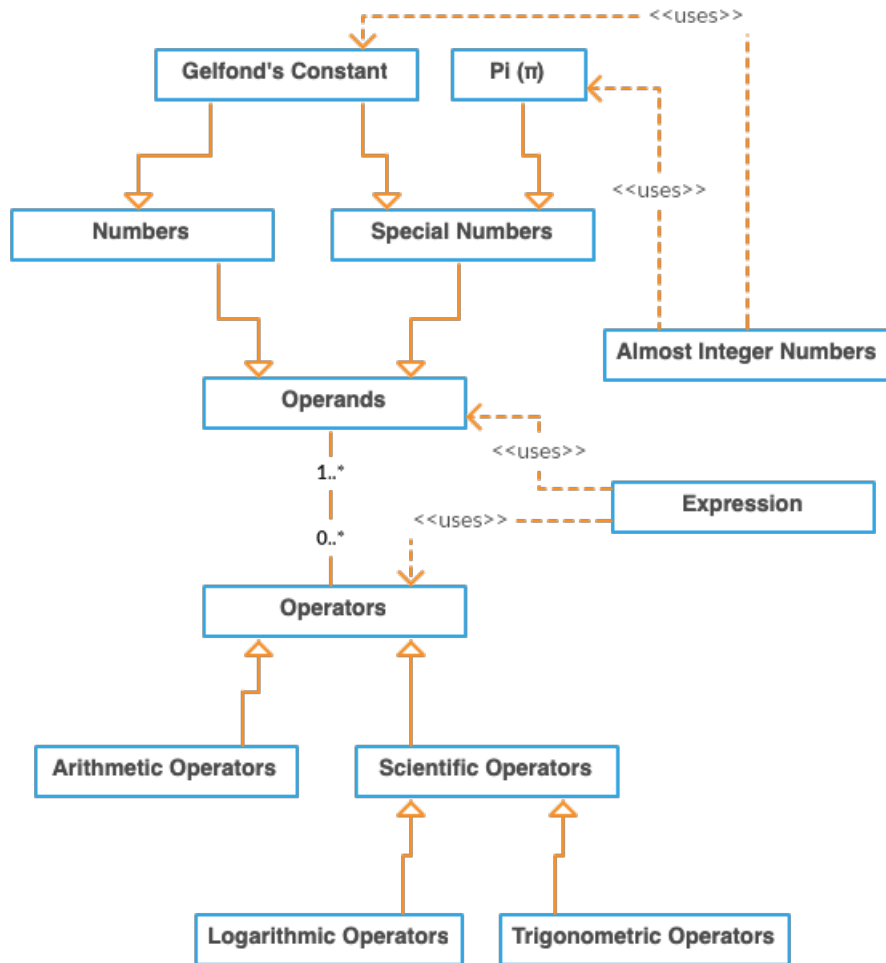
#### User Requirements

1. The calculator may contain the Gelfond's constant.
2. The calculator should have an online interface that can be accessed from desktop computer
3. The calculator should be open source.
4. The parameters inside the calculator need to be customizable
5. The calculator should be as generic as possible, that can contain more globally accepted functionalities.

#### Other Information

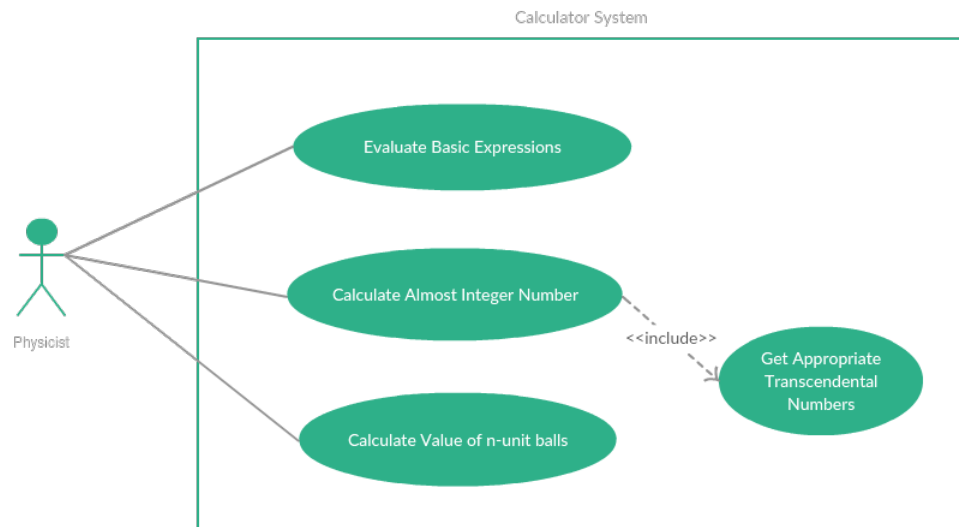
Ms Bhagat is not familiar with Gelfond's constant and does not have any implication of it in her work. But she is open to explore its applications when needed. She prefers the calculator to be an open system that can be customizable up to her needs. In future, when required, she would also like to have the Gelfond's number as part of the calculation.

## 4 Domain Model



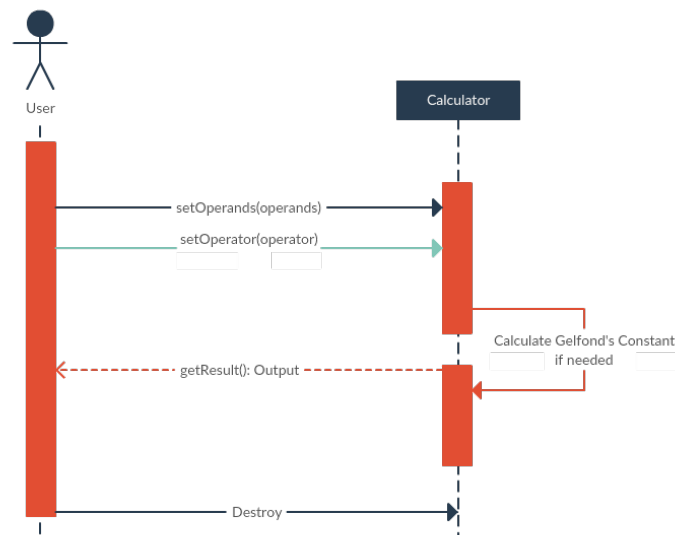
## 5 Use Case Model

### 5.1 Use Cases



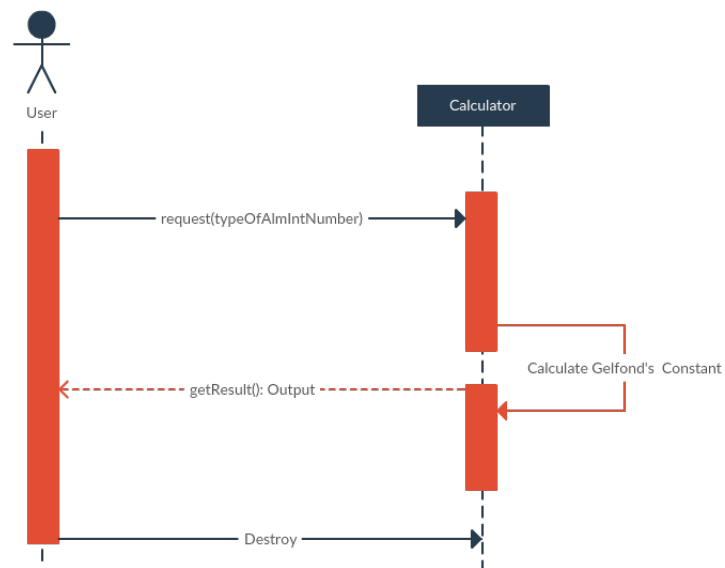
Here are the sequence diagrams for these three cases.

### 5.2 Sequence for Basic Operations

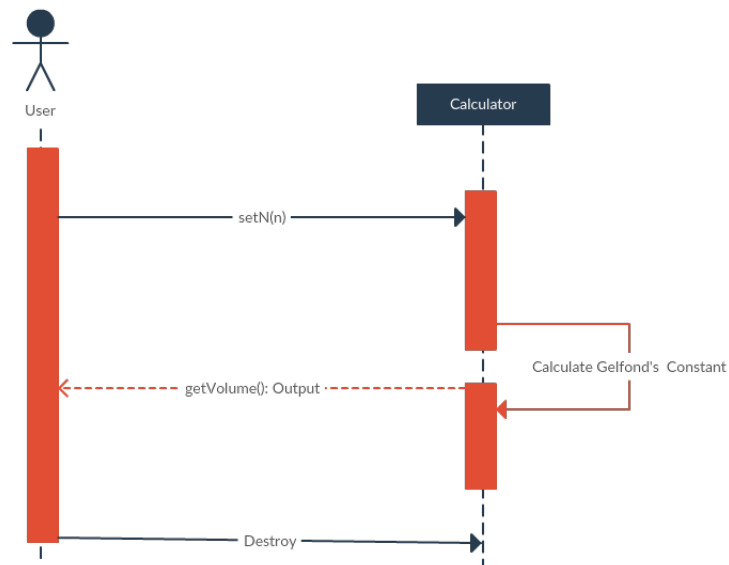




### 5.3 Sequence for Almost Integer Numbers

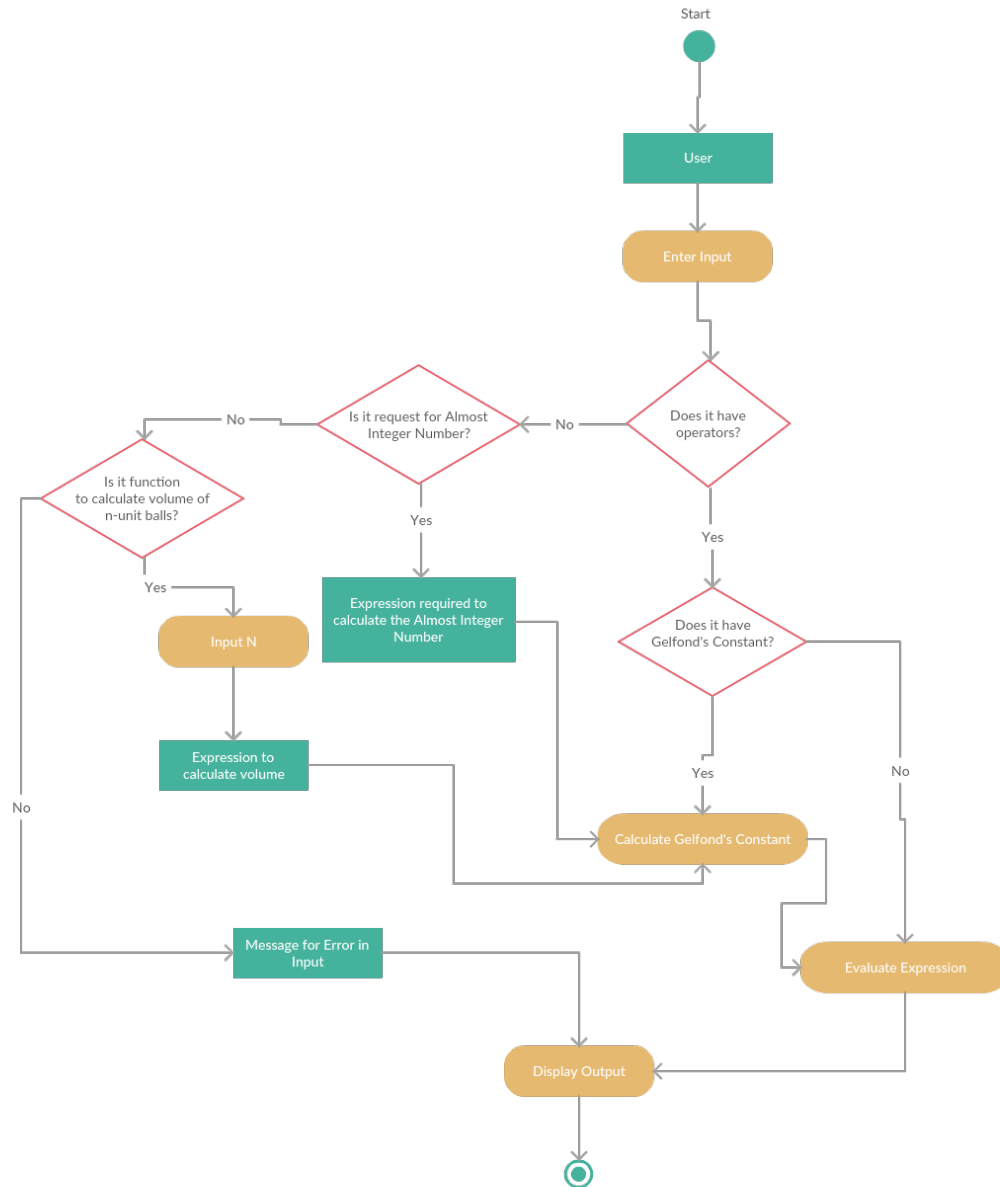


### 5.4 Sequence for n-ball



## 5.5 Sequence for

## 5.6 Activity Model



## References

- [1] Mathworld. *Gelfond's Constant*. URL: <http://mathworld.wolfram.com/GelfondsConstant.html>.
- [2] Mathworld. *Hilbert's Problems*. URL: <http://mathworld.wolfram.com/HilbertsProblems.html>.
- [3] Mathworld. *Transcendental Number*. URL: <http://mathworld.wolfram.com/TranscendentalNumber.html>.
- [4] Xianfu Wang. "Volumes of Generalized Unit Balls". In: *Mathematics Magazine* 8.5 (2005), pp. 390–395.