***Knowledge Seekers is a Role-Playing Game***
based on the novel *Faery Swap*, by Susan Kaye Quinn

Grades 5-6 (or advanced 3-4)

Students are divided into two (or more) groups, representing different Faery Houses (either House of Eyr or House of Anna). The teacher plays The Human.

**The objective:** the Faery Houses send seekers to try to convince the Human to give them the mathematical knowledge they need to increase the strength of their Houses. The Faery House with the most points at the end of the game wins (Faery Houses are always vying for dominance!).

**The House of Eyr** – Usually the ruling House, House of Eyr faeries are known for their arrogance. They are used to being in charge and are not always skilled in persuasion. House of Eyr faeries seek mathematical knowledge that would bolster their faery powers of raw strength in commanding elemental forces and dimensional magic.

**The House of Anna** – Known as the House of Art and Imagination, the House of Anna faeries are storytellers and weavers of lies. They can be very persuasive, but often change their minds. House of Anna faeries seek mathematical knowledge that would bolster their faery powers of precise manipulation of the elements and fabricating wholly new creations out of dimensional space.

**The Human** – As a member of the The Royal Society of London, the Human possesses all the best of human knowledge, in the form of **KNOWLEDGE CARDS** (below).

**KNOWLEDGE CARDS** – The best of human knowledge is encoded in equations printed on cards. Each card contains the equation, a brief explanation of how it can be used, and two point values, one for Power and one for Imagination. (Note: Knowledge Cards are ordered (1-17) from less-difficult to more-diffcult for increasing complexity with longer play.)

**HOW TO PLAY:**

1) Ancient Golden Faery Coin Toss (Susan B. Anthony coin or similar gold coin) used to determine which House goes first.
2) The Human holds the deck of Knowledge Cards (in order).
3) Each House sends a representative to get a copy of the first Knowledge Card (note: there needs to enough copies of each card that each House will have one to examine).
4) The Housed have five minutes to prepare their arguments for why the Human should make the *anam cara* (soul bond) swap with their representative (and award the Knowledge Card points to their House).
5) Each House sends a representative to present their case. They take turns trying to convince the Human (each has one minute).
6) The Human decides which House representative has made the best case for giving them the knowledge, i.e. have they

clearly stated how they will use the knowledge for improvements in the Human or Faery realms. Only one House can be awarded the points of the Card.

7) The Human rolls a six-sided dice. If the dice is number 6, the *anam cara* has failed to make a soul bond and no points are awarded. If the number is 1, the *anam cara* will be forced, and all Houses are awarded their respective points on the Card. Faeries only win the points for their House (Imagination Points to the House of Anna, Power Points to the House of Eyr).
8) Repeat with the next Knowledge Card.
9) Set a time limit for the game (say 30 minutes) – the House with the most points at the end wins. The time limit encourages the Houses not to use their full time for preparation and presentation, so they can have the most chances at earning Knowledge Card points.

The 17 Knowledge Cards are the same equations found in the book, The *17 Equations that Changed the World* by Ian Stewart, which can be used as an additional source of reference material. A blank Knowledge Card is included at the end for students who would like to research their own equation and create their own card.

**Making the Cards:** The cards are designed to print easily on one 8x11 piece of paper. Simply fold the paper in half and glue the halves together to form a card rigid enough for handling and large enough that a group of students can gather around it for study.

**Enjoy!**
**Sue**


**For more information about *Faery Swap*, a downloadable Teacher's Guide, as well as a Virtual Author's Visit video on YouTube, please see Susan's website:**

**http://www.susankayequinn.com**

# THE PYTHAGOREAN THEOREM

$$a^2 + b^2 = c^2$$

**Imagination = 2**
**Power = 5**

**What:** Calculates the length of one side of a triangle from the other two sides
**Who:** Pythagorus, Greek Mathematician, 570 BC
**How Used by Humans:**

- In GPS to triangulate your location
- In accurate mapmaking
- In video games to draw in 3D
- In construction to create a square corner

**How Used by House of Eyr:**

- To conjure faery buildings

**How Used by House of Anna:**

- To imagine details of objects
- To locate items

# KNOWLEDGE CARD ONE

# THEORY OF RELATIVITY

$$E = mc^2$$

**Imagination = 9**
**Power = 9**

**What:** Mass can be converted to energy.
**Who:** Albert Einstein, German-born American Scientist, 1879
**How Used by Humans:**

- Changed what we know about matter and energy.
- Helped create the atomic bomb.
- Helped create radioactive medicines and scanners.

**How Used by House of Eyr:**

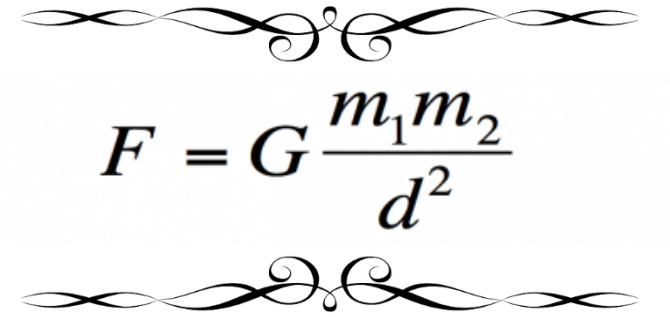
- Gives the ability to transform matter into energy and back again. Fundamental to all spells that create objects from dimensional energy.

**How Used by House of Anna:**

- Gives the ability to transform matter into energy and back again. Fundamental to all spells that create objects from dimensional energy.

# KNOWLEDGE CARD TWO

# LAW OF GRAVITY



$$F = G\frac{m_1 m_2}{d^2}$$

**Imagination = 1**
**Power = 7**

**What:** Calculates the force of gravity between two objects.
**Who:** Isaac Newton, English Mathematician, 1642
**How Used by Humans:**

- Scientists use it to understand and calculate the movement of astronomical bodies, like satellites, comets, planets, stars, galaxies, etc.
- Einstein's Theory of Relativity later showed that gravity is a warp in spacetime, not a force, but Newton's Law of Gravity still works for practical usage.

**How Used by House of Eyr:**

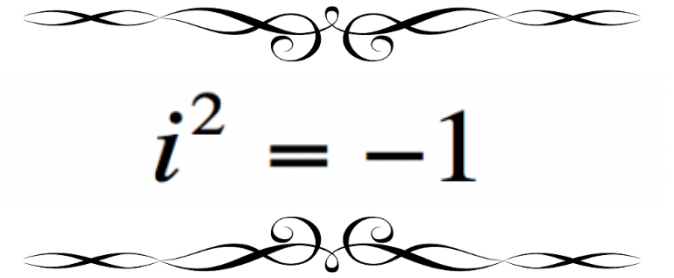
- To alter the gravitational force on Earth or the Otherworld, making things float or fly.

**How Used by House of Anna:**

- To imagine the shapes of objects if there were no gravity acting on them.

# KNOWLEDGE CARD THREE

# IMAGINARY NUMBERS




**Imagination = 9**
**Power = 1**

**What:** Imaginary numbers produce negative numbers when squared. An imaginary number line is just like a real number line, only it exists in a different dimension.

**Who:** Casper Wessel, Norweigen-Danish Mathematician, 1745

**How Used by Humans:**

- Electrical engineers use imaginary numbers to give an extra dimension to physical things we can measure, like electrical current.
- Imaginary numbers make it easier to calculate complex systems, like water flow in pipes and nuclear reactions in power plants.

**How Used by House of Eyr:**

- To conjure water elements

**How Used by House of Anna:**

- To invent objects in imaginary dimensional space before conjuring them in the real (Human or Faery) world.

# KNOWLEDGE CARD FOUR

# MAXWELL'S EQUATIONS

$$\nabla \cdot E = 0 \quad \nabla \times E = -\frac{1}{c}\frac{\partial H}{\partial t}$$

$$\nabla \cdot H = 0 \quad \nabla \times H = \frac{1}{c}\frac{\partial E}{\partial t}$$

**Imagination = 10**
**Power = 10**

**What:** Describes how electrical and magnetic fields are generated.
**Who:** James Maxwell, Scottist Physicist, 1831
**How Used by Humans:**

- Any device that uses electricity or magnetic fields uses Maxwell's Equations, including computers, radios, TV, phones.
- Laid the foundation for Einsteins Theory of Relativity.
- Helped with the discovery of radio waves.

**How Used by House of Eyr:**

- To command dimensional energy and be able to open a portal between the worlds.

**How Used by House of Anna:**

- To command dimensional energy and be able to open a portal between the worlds.

# KNOWLEDGE CARD FIVE

# SECOND LAW OF THERMODYNAMICS

$$dS \geq 0$$

**Imagination = 6**
**Power = 6**

**What:** Says the energy you get out of something will always be less than the energy you put into it, because some energy is always irreversibly lost over time.

**Who:** Sadi Carnot, French Scientist, 1796

**How Used by Humans:**

- Helps us understand of how energy moves around in the universe.
- Helped prove matter is made of atoms.
- Helped develop a better steam engine.

**How Used by House of Eyr:**

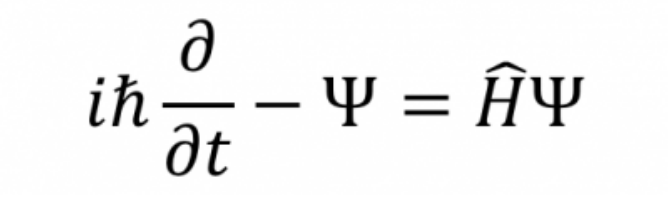
- To direct dimensional energy with minimal losses.

**How Used by House of Anna:**

- To direct dimensional energy with minimal losses.

# KNOWLEDGE CARD SIX

# SCHRODINGER'S EQUATION



**Imagination = 9**
**Power = 9**

**What:** Says matter can act as a wave as well as a particle.
**Who:** Erwin Schrödinger, Austrian Scientist, 1887
**How Used by Humans:**

- Changed our understanding of how very small particles move and behave.
- Says that particles can exist in many different states at the same time. Introduced the idea of multiple worlds existing at the same time.
- Helped develp transistors and computers.

**How Used by House of Eyr:**

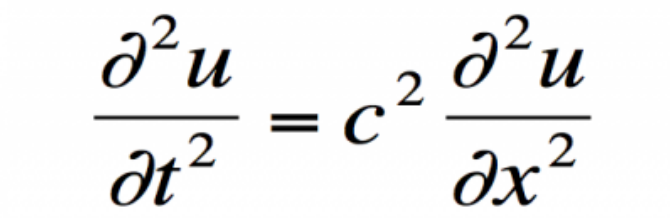
- Helps to conjure portals and move through different dimensions.

**How Used by House of Anna:**

- Helps to conjure portals and move through different dimensions.

# KNOWLEDGE CARD SEVEN

# THE WAVE EQUATION



$$\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$$

**Imagination = 6**
**Power = 9**

**What:** Describes the behavior of waves: ocean waves, sound waves, light waves, even vibrations along a violin string.

**Who:** Daniel Bernoulli, Swiss Mathematician, 1700

**How Used by Humans:**

- To understand how light and sound travel.
- To understand earthquakes (waves traveling through solids).
- Wireless technology is energy waves traveling through the air.
- Microwaves cook food in a microwave oven.

**How Used by House of Eyr:**

- To command all the elements by harnessing their wave action.

**How Used by House of Anna:**

- To send messages through spells that travel by waves through the air.

# KNOWLEDGE CARD EIGHT

# NAVIER STOKES EQUATIONS

$$\rho\left(\frac{\partial v}{\partial t} + v \cdot \nabla v\right) = -\nabla p + \nabla \cdot T + f$$

**Imagination = 6**
**Power = 10**

**What:** Describes how fluids move.
**Who:** Claude Navier, French Physicist, 1785, and George Stokes, Irish Mathematician, 1819
**How Used by Humans:**

- To predict the weather and ocean currents.
- To calculate water flow through a pipe or air flow over an airplane wing.
- To analyze the structure of molecules in creating new chemicals.

**How Used by House of Eyr:**

- To command all the flowing elements (air, fire, water) in a smooth, predictable way.

**How Used by House of Anna:**

- To make elaborate ice sculptures.

# KNOWLEDGE CARD NINE

# THEOREM OF CALCULUS

$$\frac{df}{dt} = \lim_{h \to 0} \frac{f(t+h) - f(t)}{h}$$

**Imagination = 5**
**Power = 3**

**What:** Says you can find the total value of something by breaking it into infinitely small parts and adding them up.

**Who:** Isaac Newton, English Mathematician, 1642

**How Used by Humans:**

- Calculates the area under any curve.
- Graphic artists use calculus to make realistic games and animated movies.
- Scientists use it to find the orbits of planets.
- Engineers use it to make sure bridges are safe.

**How Used by House of Eyr:**

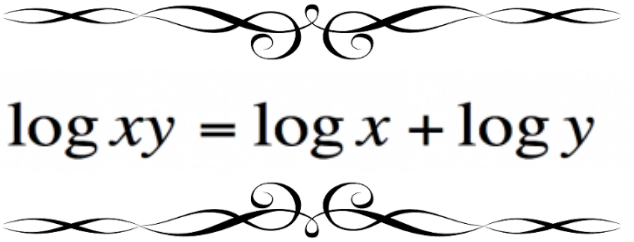
- To calculate the dimensional orbit of the Otherworld around Earth and the time between swaps

**How Used by House of Anna:**

- To imagine infinitely small or infinitely large things

# KNOWLEDGE CARD
# TEN

# THE LOGARITHM



$$\log xy = \log x + \log y$$

**Imagination = 5**
**Power = 2**

**What:** Makes multiplying faster by using addition of logarithms instead. Also used TO measure things that rapidly increase or decrease.
**Who:** John Napier, Scottish Mathematician, 1550
**How Used by Humans:**

- Before computers, made calculations faster
- Today, computer programs use logarithms for binary code (base 2, or natural, log)
- Used as a measurement scale for things that rapidly increase or decrease (Richter scale for earthquakes, Decibel scale for sound)

**How Used by House of Eyr:**

- To control elements that rapidly increase or descrease

**How Used by House of Anna:**

- To imagine infinitely small or infinitely large things

# KNOWLEDGE CARD ELEVEN

# POPULATION GROWTH EQUATION

$$X_{t+1} = kx_t(1 - x_t)$$

**Imagination = 2**
**Power = 2**

**What:** Estimates the growth of populations of creatures over time.

**Who:** Stephen Smale, American Mathematician, 1930

**How Used by Humans:**

- To predict growth of populations.
- To understand systems that are chaotic (or appear random).
- To model earthquakes and predict the weather.
- To model the growth of tumors.

**How Used by House of Eyr:**

- Not useful in the Otherworld because nothing ever grows naturally. Useful on Earth for conjuring weather spells.

**How Used by House of Anna:**

- Not useful in the Otherworld because nothing ever grows naturally. Useful on Earth for conjuring weather spells.

# KNOWLEDGE CARD TWELVE

# EULER'S POLYHEDRA

$$F - E + V = 2$$

**Imagination = 7**
**Power = 7**

**What:** A single number that describes an entire surface, no matter what shape.
**Who:** Leonhard Euler, Swiss Mathematician, 1707
**How Used by Humans:**

- Important to topology, the study of space and shape, and how one shape can be transformed into another without ripping or damaging it.
- Topology helpS chemists understand the shape of molecules and DNA.
- Topology helps engineers plan the best route over a surface for a robot to travel.
- Topology helps scientists understand how gravity warps the fabric of space.

**How Used by House of Eyr:**

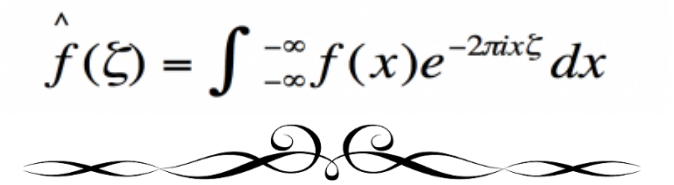
- To manipulate dimensional space to transform objects into any shape they wish.

**How Used by House of Anna:**

- To manipulate dimensional space to transform objects into any shape they wish.

# KNOWLEDGE CARD THIRTEEN

# FOURIER TRANSFORM




**Imagination = 7**
**Power = 6**

**What:** Transforms equations in one dimension (spacetime) into another dimension (waves) where they are easier to handle.
**Who:** Jean Fourier, French Mathematician, 1768
**How Used by Humans:**

- To process data with complex patterns, like filtering static out of music files or cleaning up photos and videos to make them clearer or less blurred.
- To compress computer data files.
- To analyze the structure of molecules in creating new chemicals.

**How Used by House of Eyr:**

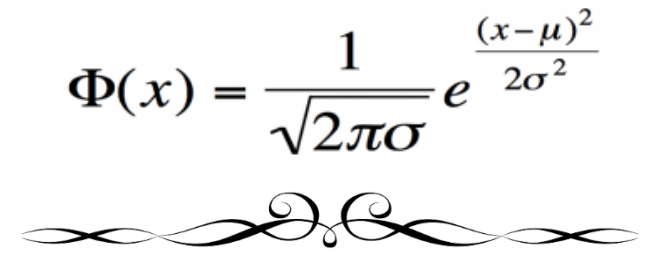
- To keep random glitches out of their dimensional spells.

**How Used by House of Anna:**

- To conjure very precise spells with fine details.

# KNOWLEDGE CARD FOURTEEN

# THE NORMAL DISTRIBUTION



$$\Phi(x) = \frac{1}{\sqrt{2\pi\sigma}} e^{\frac{(x-\mu)^2}{2\sigma^2}}$$

**Imagination = 5**
**Power = 2**

**What:** A bell-shaped curve that shows the greatest probability of something is near the average value, with less probability farther away.

**Who:** Johann Gauss, German Mathematician, 177

**How Used by Humans:**

- To estimate variation: the height of most sixth graders is close to the average, but some vary.
- To estimate the effect of randomness in studies of people or living things.
- To estimate errors in science measurements.

**How Used by House of Eyr:**

- To compensate for randomness in the elements (water, air, wind, fire).

**How Used by House of Anna:**

- To imagine possibilities that are far away from the average, most likely solution.

# KNOWLEDGE CARD FIFTEEN

# SHANNON'S INFORMATION THEORY

$$H = -\sum p(x) \log p(x)$$

**Imagination = 5**
**Power = 5**

**What:** Calculates the amount of information that can be contained in computer code.
**Who:** Claude E. Shannon, American Mathematician, 1916
**How Used by Humans:**

- To compress data without losing information.
- To send information over the internet.
- To encrypt data.

**How Used by House of Eyr:**

- To send messages by compressed dimensional energy.

**How Used by House of Anna:**

- To send messages by compressed dimensional energy.

# KNOWLEDGE CARD SIXTEEN

# BLACK SCHOLES MODEL

$$\frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial S^2} + rS\frac{\partial V}{\partial S} + \frac{\partial V}{\partial t} - rV = 0$$

**Imagination = 0**
**Power = 1**

**What:** An equation that estimates the stock market.
**Who:** Fischer Black and Myron Scholes, American Economists
**How Used by Humans:**

- Allows people to create new financial products and predict their pricing on the stock market.

**How Used by House of Eyr:**

- Not useful to faeries because they don't use money.

**How Used by House of Anna:**

- Useful only to faeries who swap with a human and try to Day Trade on the stock market to make an instant ton of money, then use that money to buy mathematical knowledge.

# KNOWLEDGE CARD SEVENTEEN

Imagination =
Power =

**What:**

**Who:**

**How Used by Humans:**

**How Used by House of Eyr:**

**How Used by House of Anna:**

# KNOWLEDGE CARD