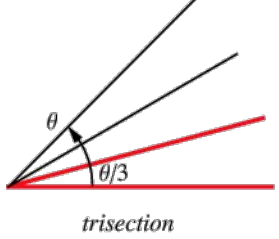
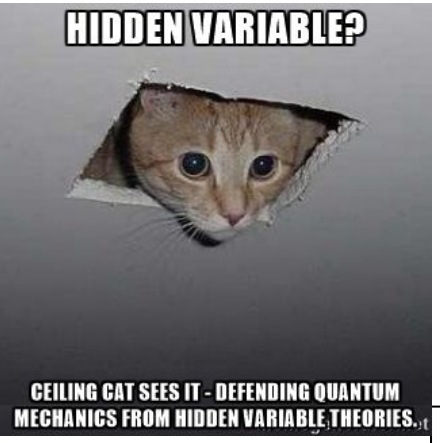
Ditch Day for Cranks
Section 1



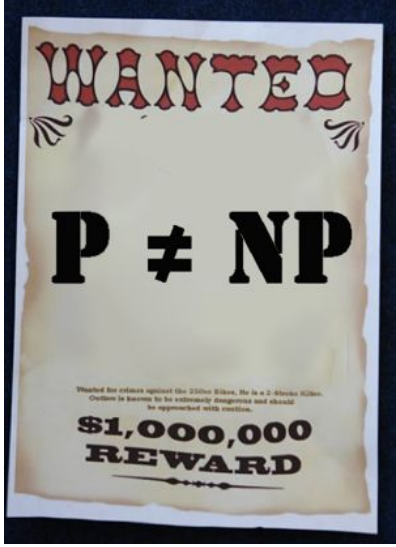
trisection

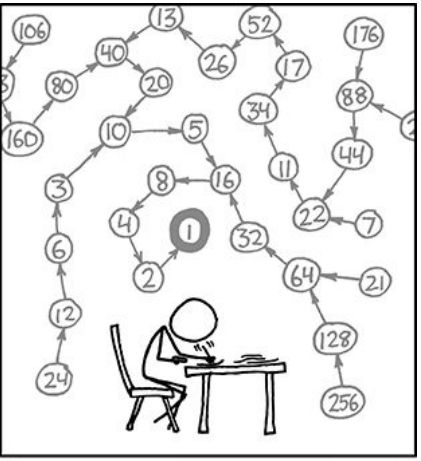


$$|\mathbb{N}| = |\mathbb{R}|$$

Limited enrollment: 3 seats

Overflow enrollment





THE COLLATZ CONJECTURE STATES THAT IF YOU PICK A NUMBER, AND IF IT'S EVEN DIVIDE IT BY TWO AND IF IT'S ODD MULTIPLY IT BY THREE AND ADD ONE, AND YOU REPEAT THIS PROCEDURE LONG ENOUGH, EVENTUALLY YOUR FRIENDS WILL STOP CALLING TO SEE IF YOU WANT TO HANG OUT.

PROOF:

$e^{i \cdot P_i} = -1$

And,
$P_i = P \cdot i$

So,
$e^{i \cdot P_i} = e^{P_i \cdot i} = e^{-P}$

So,
$e^{-P} = -1$

Squaring both sides.
$e^{-2P} = 1$

Which leaves
$P = 0$

Thus,
$P = NP$
QED

$$\mathrm{Con}(\mathrm{ZFC})$$

$$f : n \mapsto n^{\text{th}} \text{ prime}$$

$$f \in \mathsf{P}$$

Authorship and Acknowledgements

This PDF comprises the material for a fake Ditch Day stack run on Oct 21, 2016, authored by Jalex Stark.

The author would like to thank the following people:
Thanks to Nets Katz for playing the role of BED 1a professor at the end of the stack, and for teaching the Caltech Ma1a on which much of this stack was based. Thanks to Kirby Sikes for helping compile and distribute the stack elements, and for playing the role of TA during the stack. Thanks to Nicholas Schiefer, William Hoza, and Matthew Morgan for useful conversations during the writing phase.

BED 1a Class Syllabus

BED 1 is a class teaching the fundamentals of Ditch Day. BED 1a focuses on the axiomatic foundations of Ditch Day construction with an emphasis on ambiguously constructive proofs. If time permits, students will prove the Fundamental Theorem of Ditch Day. Starting in the second tem, BED 1b, students may elect to switch to the practical track, with a pointed emphasis on going to bed.

Recommended Textbooks

- *"Ditch Day for Cranks" lecture notes.* For convenience, each week's lecture notes can be picked up along with the week's problem set at the TA office hour. The full PDF will also be made available at the professor's website at the end of the year.
- *Wikipedia.* In particular, the "list of" pages shall be quite useful. See, for example, https://en.wikipedia.org/wiki/List_of_lists_of_lists
- *Every sufficiently popular journal article in the fields of math, physics, and computer science published after 1970.* In particular, any paper with at least 10000 citations will be assumed background knowledge.

Collaboration Policy

Collaboration is required on all problem sets, quizzes, and exams. A list of allowed resources will be given with each assignment.

Grading Policy

BED 1 is graded on a Pass/Pass basis. All assignments are optional; please see the TA if you'd like an exemption.

Office Hours

The TA for the class is Kirby. Their office hours will be held from 8 AM to 9 AM Tomorrow morning in Dabney courtyard.

Unfortunately, your TA did not Go To Bed early enough tonight, so they're rather tired Tomorrow. **Your first task is to find and deliver to them three differently-named stimulants. Otherwise, they'll just groan at you instead of giving you hints.**

1 Week 0

Definition 1.1 (Ditch Day)**.** A *Ditch Day stack* is a series of activities constructed by a senior or group of seniors, sometimes referred to as the *stackers*. These activities are typically constructed with the aim of encouraging intra-group interaction while exploring fun ideas. Participants in a stack are often referred to as *stackees*.

Theorem 1.2 (Fundamental Theorem of Stack Participation)**.** *Stacks are fun!*

Proof. Left as an exercise for the stackees. □

Corollary 1.3. *If at any point you believe that an assignment is asking you to take actions that aren't fun, (e.g. you feel required to leave campus, break institute policy, or assume risk of bodily injury) please stop and ask the TA for clarification.*

Definition 1.4 (Stimulant)**.** *Stimulants* are a class of drugs that offer a temporary boost in alertness and wakefulness. Some of the most common stimulants include caffeine, amphetamines, nicotine, and cocaine. Stimulants are used by some academics to enhance performance, especially in the context of performing computations.

Proposition 1.5 (Rényi)**.** *A mathematician is a machine for turning coffee into theorems.*

It is often joked that a "comathematician" is a machine for turning "cotheorems" into "ffee". For an explanation of this joke, utter the words "category theory" near any math major in Dabney.
(Warning: category theory is Schedule I mathematical machinery. Category theory may irreversibly change your outlook on the mathematical world. Please consult your advisor before taking category theory.)

Example 1.6. Mathematician Paul Erdös' use of amphetamines is so prolific that he was once offered a $500 wager on the condition of abstaining for four weeks. Erdös, fond of winning bets, "stayed clean" for the required period. After collecting his winnings, he complained that *the progress of mathematics had been set back by a month.*

2 Lecture Theory

Definition 2.1 (Paper Puzzle)**.** A *Ditch Day paper puzzle* is an intellectual activity designed to blend problem-solving elements with humor specific to the subcultures of the stackees. Often, the stated rules of the puzzle are designed to conceal important details about its method of solution. Stackees are expected to infer hidden rules of the puzzle during the process of solving it.

Theorem 2.2 (Fundamental Theorem of Paper Puzzles)**.** $3^3 = 2^5 = 5^2 = 26$.

Proof. By construction. Enroll in EE51, then design and build a calculator. Use it to test the above equalities. □

The Fundamental Theorem of Puzzles is summarily useful for encoding alphabetic messages in combinatorial structures.

Example 2.3. We demonstrate an application of only the last equality in the theorem. Suppose we have any five element set, for example {A,E,I,O,U}. There are $5^2 = 26$ ordered pairs of elements from this set, so we may put it in bijection with the alphabet. A canonical bijection is depicted in the diagram below.

AA	AE	AI	AO	AU
EA	EE	EI	EO	EU
IA	IE	II	IO	IU
OA	OE	OI	OO	OU
UA	UE	UI	UO	UU

=

∅	A	B	C	D
E	F	G	H	I
J	K	L	M	N
O	P	Q	R	S
T	U	V	W	X

Definition 2.4 (Lecture Theory)**.** *Lecture theory* is a set of results by which a rational agent may make deductions based on the form of presentation of content, especially as opposed to making deductions from the content itself.

Example 2.5. A professor draws a circle on a whiteboard and says. "This disk has 1 region." Then they draw a line through the circle. "If we draw one line through the disk, it has 2 regions". They draw another line, "3 lines make 8 regions". They draw another, putting a dot in each of the regions in the disk. "and of course, 4 lines make 16 regions." The professor asks the class A smartass student raises her hand. "You've made a point of rushing through that calculation without letting us do it ourselves, and you have an evil smirk on your face. I'm inclined to think that you're trying to trick us into thinking that the number of parts of the disk induced by n lines is 2^n, just so that you can smugly tell us that it's not true."

The professor was dumbfounded. The audience fell silent. All awaited the student's conjecture. "By the way, professor, your underwear is showing."

Homework # 2: Lecture Theory **due: Tomorrow**

Allowed resources: This problem set is open everything, except that you may not reference an answer key. The recommended course texts are particularly helpful. Use of a whiteboard or shared spreadsheet is encouraged.

This problem set is difficult. Ask for hints if you are stuck. The scaffolding of the problem is intended to be helpful and not misleading.

Definition 1 (Cryptic Crossword)**.** A cryptic crossword puzzle is a crossword puzzle in which each of the clues is itself a word puzzle. The clue consists of a definition for the answer, a transition phrase, and then a wordplay on the answer.

On this problem set, the clues marked with "?" are cryptic clues.

Example 1*.*

Consumes a portion of meat stew.[1]

The first word "consumes" is a definition. The phrase "a portion of" indicates that the answer is a substring of "m**eat s**tew". The answer is EATS.

Example 2*.*

Rewrite article for narration

"Rewrite article" clues that the answer is an anagram of "article." "For" is a linking word and "narration" is a definition. The answer is RECITAL.

Problems:

1. I am thinking of a video game. Which is it? Use the 24 clues on the next page to deduce the answer. Each clue has an answer which is a common word, proper noun, or word fragment.

   (a) Find a set of constraints such that the answer to each clue is unique. There are global constraints that apply to all answers and a constraint on how the answers in each group relate to each other.

   (**Hint:** *The cryptic clues have unique answers without considering any constraint.*)

   (b) Find as many answers to clues as possible.

   (c) Extract the name of a video game from the (ordered and grouped) list of answers. Lecture theoretic deductions will be helpful here.

[1]Examples 1 and 2 taken from http://www.telegraph.co.uk/games/10527732/A-guide-to-cryptic-crosswords.html

prefix -the**a**ter, -polis
boxer i**n** Islam?
video game pub**l**ishing company

cactus starring in **E**xcellent Inventions
berry o**f** Hawaii
small town in stanly **c**ounty, North Carolina

continent adju**s**ting aria use?
plant genus with speci**e**s cupreata and reptans
competitor t**o** Travelocity

Scottish fish **a**nd chips chain
excessive quantity of a brea**d** roll choreographed routine?
describes a 2-ary operation unamb**i**guously extending to an n-ary one

first name of actor i**n** “Herbie Rides Again”
in three feline, e**n**d of cave complex?
prevent fro**m** ever dying

zero calorie **f**at substitute
preside**n**t of US
small ensemble adj**u**sted tenor chairs?

first mass-produce**d** phase-shifter box
remove a plant orally **f**arther along the path?
not notic**i**ng things

Mayan ruin locate**d** in modern Belize
Leicester City for**w**ard from Argentina
Alas, pup excit**e**d Swedish city?

3 Object Manipulation

Definition 3.1 (Physical Puzzle)**.** A *Ditch Day physical puzzle* is a stack element designed to show off cool properties of the universe. Well-designed physical puzzles take advantage of the stackee's natural inclinations towards investigation in order to maximize the *stack design efficiency ratio*

$$S = \frac{\text{time engaged with activity}}{\text{complexity of activity}}$$

Often S is inflated by requiring the stackees to accomplish an arbitrary task.

Example 3.2. A clue leads the stackees to DEI. They notice a piece of paper taped to the middle of the pool table with the following challenge: "Can you throw a pool ball such that it bounces off of each wall of the pool table twice before coming to a rest?"

Such a physical challenge lies just outside the physical capabilities of the stackees, and has the critically addictive property that the progress towards completion is a nonlinear function of effort expended.

Theorem 3.3 (Fundamental Theorem of Physical Puzzles)**.** *Fix in advance any physical puzzle $\mathcal{P}$. Despite many hours of beta testing, $\mathcal{P}$ will irreversibly break Tomorrow.*

Proof. See Ditch Day 2015, 2014, 2013, 2012, etc.. □

Unlike previous theorems, this one is *not* an exercise for the stackees. Try not to drop the acryclics.

New Word 3.4 (Game of four)**.** A *word bit* is an atom of a word. Each word is made of many a word bit. When one does talk in *the game of four*, one does take care to use a word only if it has at most four word bits. If one does fail in this task, one proclaims "Down in fire!".

Some of the time, as in the case of a talk by a prof, a word has lots and lots of word bits. In a time like that, one may feel lost. But this is easy to fix! If you talk in the game of four, you don't use any word that does make one feel lost. xkcd also does a feat like this in "up-goer five". They use a way to not only make a word less long, but also to make a word easy for sure. In our way, we also make the same goal that xkcd does.

New Way 3.5 (The way of two and one)**.** In *the way of two and one*, one may use a bit and a bit and a bit, but not a bit and a bit and a bit and a bit. The way of two and one is a bit too let-not-say for us, so we do not use it. You may use it on **ur** own, **tho**.

Homework # 2: Object Manipulation **due: Tomorrow**

Allowed resources: Use of hands, feet, other body parts, and cell phone cameras are explicitly encouraged. Use of the internet is discouraged—please cite any sources referenced.

Problems:

1. There are six *acrylic balls* and one *laser pointer* in this room. The laser pointer is fixed in space. The balls are free to move.

   (a) Without moving the laser pointer, cause the beam to pass through all 6 balls and shine on the wall directly behind the pointer.

   (b) Extending this, experimentally determine a lower bound on the maximum positive angle between the end of the beam and the source of the beam. Acquire photographic evidence.

   (c) There is a light filter next to the laser. Screw it onto the laser. Roll a ball in front of the laser. Play with this and other effects ad nauseum. Take video evidence of any phenomena which deserve future study.

   (d) Return the objects to the arrangement in which you found them, taking care to remove the light filter if it is attached.

2. Suppose we have a countable sequence of independent identically distributed clipboards, each of uniform density and rectangular prism shape. It is a classical result of Newtonian mechanics that in a stack of such clipboards, the maximum possible horizontal displacement between the top clipboard and the bottom clipboard grows without bound as the stack increases.

   (a) Find a way to show this fact. When you show it, use a word only if it has four or less word bits.

   (**Hint:** *Take care when you say a word like 7, that is, five and two. Some ways to say it use more than four word bits.*)

   (b) Give numerical evidence for this fact. In particular, demonstrate that the projections of the top and bottom clipboard onto the $\hat{\mathbf{g}}^{\perp}$ plane need not overlap (where $\hat{\mathbf{g}}$ represents the gravitational field). Preferred formats for your proof are JPEG, MP4, or Coq. (**Hint:** *Stack the clipboards such that the bottom clipboard is entirely in contact with the table and the top clipboard is not over the table.*)

4 Lecture Notes: Fetch Quest

Definition 4.1 (Fetch Quest)**.** A *Ditch Day fetch quest* consists of a finite set of objects O together with a compact subset D of campus, together with a function $f : O \to D$. In some cases, the stackees may be asked to find f as part of the puzzle. Typically, the purpose of the quest becomes clear as the set $O \cap \text{Neighborhood(stackees)}$ grows large.

Example 4.2. You're on one. If you haven't started walking yet, start now.

While Fetch quests are often seen as onerous, pointless, or boring, a well-designed fetch quest provides a good opportunity for stackees to socialize with each other and achieve group bonding. To illustrate the importance of fetch quests, please consider the following as you trot around campus:

Theorem 4.3 (Fundamental Theorem of Algebra)**.** *Every polynomial with complex coefficients has exactly n roots over C, where roots are counted with multiplicity.*

Proof. See problem 4 of problem set 8 of Ma1a, Fall 2013. □

Homework # 3: Fetch Quest **due: Tomorrow**

Allowed resources: This problem set is open everything, except that you may not reference an answer key. The recommended course texts are particularly helpful. Use of Mathematica or similar computational software is recommended.

Problems:

1. I thought of an integer between 0 and 1008. Guess what it is.

   The professor's office hours begin at 9 AM. If you haven't solved this puzzle by 08:55, ask the TA to refer you to their office. (You'll be able to continue working on the problem after office hour if desired.)

   There are several hints around campus. You'll need as many as possible. In the recommended text for the class, it's proved that you can't reliably guess the answer with less than k of the clues. I originally set k = 20, but the TAs recommended against having a problem set in a core class which requires proving the **Fundamental Theorem of Algebra**. In order to leave that in as an optional bonus problem, I lowered the value of k a bit. In any case, there were already *way too many k's*.

   - This clue really likes the smell of Darb feet.
   - This clue is helping flood the courtyard for Drop Day.
   - This clue forgot its ID, so it entered Dabney by exploiting a well-known security flaw.
   - This clue came to rest in the courtyard after an interstellar flight.
   - This clue lives underneath a small piece of metal on the Dabney porch.
   - This clue lives underneath a small piece of metal in the Large Hadron Collider.
   - This clue practices the Beatles' music underground.
   - This clue practices underground music with the Beatles.
   - This clue is in a concrete box. It will eventually catch on fire.
   - This clue is inside the sun. It's probably too late to retrieve it.
   - This clue is inside the Dabney President's desk.
   - This clue is inside President Rosenbaum's desk.
   - This clue is pondering its quest as it sits on a rock.
   - This clue is pondering relativity as it sits at $0.9c$.
   - This clue exists in a three-dimensional reality embedded in our own.
   - This clue exists in an embedding of our world into (9+1)-dimensional string theory.
   - This clue is **the smallest Gödel number for a proof of the FTA**.
   - This clue is derived in unpublished lecture slides, A. Kitaev
   - This clue is not measurable, but its existence can be proved with the Axiom of Choice.
   - This clue is chosen uniformly at random from the finite field with 1009 elements.

Lecture Theory Solution

Note: This puzzle and solution set were originally written as a standalone object with absolutely no instruction. Much of the material here is redundant with the material in the problem set and lecture notes. You're presented with eight groups of three clues, centered on the page. The clues mostly look like crossword clues , and some of them are easy to solve.

For example, if you google "cactus starring in Excellent Inventions", you'll discover a BBC show called "Ed and Oucho's Excellent Inventions", in which Oucho is the name of a talking cactus. So the answer to this clue is OUCHO.

But then some of the clues are a little ambiguous, eg. "competitor to Travelocity". This wikipedia page suggest that there as many as 50 reasonable answers to this clue. Something fishy is going on.

Furthermore, some of the clues sound very strange and end in question marks. These are cryptic clues, which you can read more about here. (familiarity with these is expected in the target audience of this puzzle)

The basic idea is that part of the clue is a standard crossword definition, while part of the clue is wordplay. For example, "boxer in Islam?" clues the answer ALI. Muhammad Ali satisfies the definition "boxer", and also the letters of Ali appear in the letters of Islam. (As a fun bonus, Muhammad Ali is follows the religion of Islam.)
"continent adjusting aria use?" has as definition "continent", and then "adjusting" is a standard cryptic clue meaning "the answer is an anagram of the rest of the clue". Therefore, the answer is EURASIA.

Knowing how to solve two kinds of clues, armed with a little bit of google-fu, you collect seven puzzle answers, just the few that are easiest for you.

```
?
ALI
?

OUCHO
?
?

EURASIA
EPISCIA
?

?
```

```
?
?

?
?
?

?
?
ORCHESTRINA

?
UPROUTE
?

?
ULLOA
?
```

At this point, you hopefully notice that every clue starts and ends in a vowel. This is a powerful constraint! It instantly gives you that "president of US" clues OBAMA.
Looking at a list of small towns in Stanly County reveals OAKBORO.
Googling "berry hawaii" pretty quickly suggests OHELO

However, this constraint is not quite enough.

Looking at the IMDb cast list for Herbie Rides Again, you find both of the first names "Iggie" and "Elaine" among the cast.
Looking at the list of travel agencies, you find "Expedia", "Odigeo", and "Opodo".

You're a little bit stuck on clues, and you decide to step back and think about how you're going to extract an answer. You realize that the clues were presented to you in centered form, so you center your answers. You notice that they all have a middle letter, which in particular means that they all have odd length. So it must be that "Iggie" is correct and "Elaine" is not!

Furthermore, you now have three groups of clues in which you've gotten two answers. (OUCHO, OHELO), (EURASIA, EPISCIA), and (OBAMA, ORCHESTRINA). In each of these groups, the answers start and end with the same pair of letters. Now we know that the Travelocity competitor must be EXPEDIA.

We have all the constraints we need: every answer has an odd number of letters, starts and ends with a vowel, and these vowels are the same as the other two clues in its group. Now we

can solve all of the clues. (In practice, we only solve most of the clues. Some of these, especially the cryptics, are pretty obscure.)

AM**P**HI
A**L**I
AT**A**RI

OU**C**HO
OH**E**LO
OAK**B**ORO

EUR**A**SIA
EPI**S**CIA
EXP**E**DIA

ASH**V**ALE
ABUN**D**ANCE
ASSOC**I**ATIVE

IG**G**IE
INTR**I**CATE
IMMOR**T**ALIZE

OLE**S**TRA
OB**A**MA
ORCHE**S**TRINA

UNI**V**IBE
UPR**O**UTE
UNA**W**ARE

UXB**E**NKA
UL**L**OA
UPP**S**ALA

From the problem set, you know that the answer to the puzzle is a video game title. We have eight groups of clues, and eight is a reasonable number of letters for a video game title. So now we want to extract one letter from each group of clues.

Remembering that each of these words has a middle letter, you read down the spine. This gives you the clue phrase PLACEBASEVDIGITSASVOWELS.

Alright, so now we've got to do something with vowels. Each group of three clues gave us a distinct vowel pair. None of these vowels are Y, so let's think of the phrase "there are exactly five vowels" as true. The clue phrase tells us something about BASEV. V is the roman numeral for five. So let's do what it tells us: take the vowels we have and replace them with base-five digits. A = 0, E = 1, I = 2, O = 3, U = 4. (This is a natural thing to do in a hardcore puzzle-solving context; we wouldn't leave anything nearly this complex unclued in a puzzle for a more general audience.) Then we're left with a list of numbers whose value is each less than 26, by construction. Then we do the most natural thing, and apply the number-letter cipher (A = 1, B = 2,... Z = 26). The answer to the puzzle is BREAKOUT.

```
     AEIOU
     01234
AI = 02 =  2 = B
OO = 33 = 18 = R
EA = 10 =  5 = E
AE = 01 =  1 = A
IE = 12 =  7 = K
OA = 30 = 15 = O
UE = 41 = 21 = U
UA = 40 = 20 = T
```

Fetch Quest Solution + Implementation Details

The following are points on the curve x \mapsto 719 x^4 + 724 x^3 + 7 x^2 + 364 x + 164 (mod 1009). The idea behind the decoding scheme is explained in detail in Adi Shamir's paper "How to Share a Secret". The polynomial is of degree four, so they can solve for the answer whenever they have found 5 of the clues. The answer is Nets Katz' office number in Sloan. Katz is expecting students to come to his room around 9 AM.

0 \mapsto 164;
1 \mapsto 969; 2 \mapsto 54; 3 \mapsto 404; 4 \mapsto 62; 5 \mapsto 201;
6 \mapsto 79; 7 \mapsto 66; 8 \mapsto 635; 9 \mapsto 344; 10 \mapsto 881

The TA should have two copies of Shamir's paper. If a section asks for a hint, the TA should respond by telling them that the prof gave them this paper to read, but they never got around to it. The TA should then hand over the paper.

Each clue is a piece of paper with one point of the curve, together with two Tarot cards. Each section should take one of the Tarot cards from each clue they visit, leaving the other undisturbed.

The clues are hidden at the following locations.

- This clue really likes the smell of Darb feet. **Box of shoes in Dabney lounge.**
- This clue is helping flood the courtyard for Drop Day. **Underneath the grate covering a courtyard drain.**
- This clue forgot its ID, so it entered Dabney by exploiting a well-known security flaw. **On the outside of the unlocked external door into Alley 7.**
- This clue came to rest in the courtyard after an interstellar flight. **On the pentagonal UFO on top of the shed in Dabney courtyard.**
- This clue lives underneath a small piece of metal on the Dabney porch. **Underneath an discarded metal canister in the ceramic lattice on the upper main porch.**
- This clue practices the Beatles' music underground. **In a music practice room in the SAC.**
- This clue is in a concrete box. It will eventually catch on fire. **Taped to the back of the fireplace (AKA "warmbox") in the lounge.**
- This clue is inside the Dabney President's desk. **In D48, in the drawer underneath Jalex's desk.**
- This clue is pondering its quest as it sits on a rock. **On the rock near the turtle pond, featured during the "Ball meets friend" skit of the rotation video.**
- This clue exists in a three-dimensional reality embedded in our own. **Taped to the HTC Vive in DEI.**