# Sestinas and Golden Shovels

Carol Dorf[1] and Lisa Lajeunesse[2]

[1]Mathematics Department (retired), Berkeley High, Berkeley; carol.dorf@gmail.com
[2]School of STEM, Capilano University, North Vancouver, Canada; llajeune@capilanou.ca

## Abstract

This workshop introduces participants to two poetic forms with mathematical content, one ancient and one modern: the sestina and the Golden Shovel. Similarities and differences are highlighted and participants are guided through the process of writing their own poetry in each of these forms. At the end of the workshop, participants will have an opportunity to share their poetry. Educators who attend this workshop will find that the methods they learn can be easily adapted for secondary students or post-secondary students in a math course for non-science majors.

## Introduction

In this workshop, we introduce two poetic forms and explore their mathematical possibilities. These forms are the sestina, a permutation-based 12th century form, and Golden Shovel, a constraint-based form created in the beginning of the 21st century. Although the creation of these two forms is separated by over 800 years, the forms share a striking similarity: each one fixes the last word of each line in the poem. The sestina relies on a recurring permutation to place the last words of each line. In contrast, the Golden Shovel relies on the post-modern technique of referencing a prior text. For the purpose of this paper, we discuss each form separately, however in the workshop setting, we will point out parallels and contrasts as they arise between the two forms.

The workshop will allocate 35 to 40 minutes to each form. Each portion will consist of a 10 – 15 minute introduction to the form, including advice on how to choose the 6 words (for the sestina) or quote (for the Golden Shovel). For participants who want more guidance, the workshop leaders will provide ideas for word choices as well as suitable quotes from a variety of mathematicians and physicists. After learning how to position the final words of each line, participants will spend the balance of time writing a poem (about 20 – 30 minutes for each form). During the last 10 to 15 minutes, we will invite participants to share one of their poems, as well as any observations or comparisons they have on the forms themselves. Depending on attendance and time constraints, this sharing might occur in small subgroups.

## The Sestina

The sestina dates from late 12th century Provence and is attributed to troubadour Arnaut Daniel, whose poem *Lo ferm voler qu'el cor m'intra* (tr. *The firm desire that enters*) is the earliest known example of a sestina. Sestinas written by Dante and Petrarch in the 13th and 14th centuries helped spread the form and eventually it found its way to England, with the first English sestina penned by Edmund Spenser in the 16th century. In the last century, poets such as Elizabeth Bishop, Ezra Pound, W.H. Auden, and Marilyn Hacker have written sestinas [6]. Its continued use by such poets over a span of roughly 850 years is a testament to the sestina's enduring appeal.

Though poets have experimented with minor variations on the sestina, an essential ingredient is that the six words that end the six lines of the first stanza, also end the six lines of the remaining 5 stanzas. As the poet transitions from one stanza to the next, a fixed permutation reorders the positions of these words. The sestina does not require a rhyming scheme, and perhaps this flexibility has played a role in its longevity. In its most common form, the permutation used is the same cyclic permutation that Arnaut Daniel introduced many centuries ago. This permutation is applied five times to produce a total of six stanzas, comprising 36 lines. Three additional lines follow the six stanzas, forming the tercet or envoi. The six

words appear one last time in the tercet. Each line of the tercet contains two of the words, one of which ends the line. The order in which the six words appear in the tercet has a number of variations. Because of their frequent repetition, the six words become an echoing force, running like six separate threads through the poem and adding structure.

We can reconstruct the sestina's pattern from Carol Dorf's sestina *Dust for My Sake* included below. Table 1 shows the positions of the six words in each stanza. Each word is distinctly shaded to help us trace its changing position through the poem. Note that each word appears once in each row and column.

**Table 1:** *End-of-line words in Carol Dorf's "Dust for my Sake."*

| | **Stanza 1** | **Stanza 2** | **Stanza 3** | **Stanza 4** | **Stanza 5** | **Stanza 6** |
|---|---|---|---|---|---|---|
| **Line 1** | sake | keep | sea | hold | think | connections |
| **Line 2** | connect | sake | keep | sea | holds | think |
| **Line 3** | sea | held | thinks | connect | sake | keep |
| **Line 4** | think | interconnected | sake | keep | sea | hold |
| **Line 5** | hold | think | disconnect | sake | keeps | sea |
| **Line 6** | keep | sea | hold | thinks | connected | sake |

The permutation is reconstructed by examining how the positions of the words change from the 1st to the 2nd stanza. The reader will notice (for example) that the word that ends line 1 in each stanza always ends line 2 in the next. This is because the permutation describes not only how the words are reordered from the first to second stanza but also from each stanza to the one that follows.

This permutation is an example of a *cycle*, or *cyclic* permutation. Note that each word cycles through each possible position. If we follow the changing position of the word "sake" (highlighted in yellow in Table 1), we see it ends lines 1, 2, 4, 5, 3 and finally line 6 as it moves through the six stanzas. This sequence gives us the notation $\sigma = (124536)$, for the sestina's particular cyclic permutation.

We can think of the cyclic permutation $\sigma = (124536)$ as an infinite sequence of repeating positions

$$\sigma = \cdots \underbrace{1\,2\,4\,5\,3\,6}\ \underbrace{1\,2\,4\,5\,3\,6}\ \underbrace{1\,2\,4\,5\,3\,6}\cdots$$

Thinking of it this way we can find the sequence of positions for any of the 6 words. For example, to map out the word "sea", notice that it ends line 3 in the first stanza. We can read its position in the stanzas that follow by starting at any occurrence of 3 in the infinite sequence.

$$\sigma = \cdots 1\,2\,4\,5\ \ \underbrace{3\,6\,1\,2\,4\,5}_{\text{Sequence of line positions for "sea"}}\ \ 3\,6\,1\,2\,4\,5\,3\,6\ldots$$

The permutation is called a cycle because if applied a 6th time (to create a 7th stanza) each word would return to its original position.

*Dust for My Sake* by Carol Dorf

Two notes: 1) I am dust. 2) For my sake
the world was created. Together they connect
despair and the grandiose, create the sea
between worlds for neo-kabbalists to think
into being; an earth with gravity to hold
the atmosphere and the waters, to keep

all from shooting off into space, to keep
each box of memory intact for the sake
of the children who don't forget being held
against a mother's chest, interconnected
heartbeats giving both space to think
again after infant misery and its sea

of tears. Walking a path above the sea
shore she remembers rocking a child to keep
the peace in a disintegrating house she thinks
belonged to someone for whose sake
she was told to hush, to disconnect
impulse from expression, and to hold

still, god-dammit; what has become of her hold
on the storyline? Bring back the sound of the sea
with sanderlings rushing waves, that connect
the earth and the oceans. Even now they keep
sliding their thin beaks into the sands for the sake
of their next meal but somehow she thinks

it refers to continuity, the way when we think
of the long-gone complete with suitcases, it holds
them in this world, not really for their sake
but as a ballast against the rising sea
which absorbs barrier islands and keeps
reminding us that all the oceans are connected

underneath. We need to map connections
as we build globes, however many ways we think
up to distract ourselves, plans that keep
enumerating distinctions that hold
separate dust and sands that underlie the sea.
Who has the chutzpah to say, “For my sake,

the planet keeps to its course, holds
steady; when I think of the sea,
I remember dust. For my sake.”

While the notation $\sigma = (124536)$ uniquely describes the permutation's action, somehow it does not capture the elegance of the sestina's permutation. For this, it is better to focus not on each word's destination, but instead, on where each word came from. By examining the order in which the words are *drawn from* the previous stanza, we see that the word in line 1 of the 2nd stanza is from line 6 of the 1st stanza, the word in line 2 of the 2nd stanza is from line 1 of the 1st stanza etc. Continuing this analysis gives the pattern 6 1 5 2 4 3.

More simply, we look to the last line, then the 1st line, then the 2nd last line, then the 2nd line, then the 3rd last line, then the 3rd line to draw the word order for the next stanza. At some point in the early 1960's, Eugene Vinaver, professor of French at the University of Manchester, mentioned that the pattern of the sestina suggests a spiral [8]. Since then, the spiral image often appears in discussions of the sestina. The authors have created the diagram in Figure 1 to illustrate this spiral.

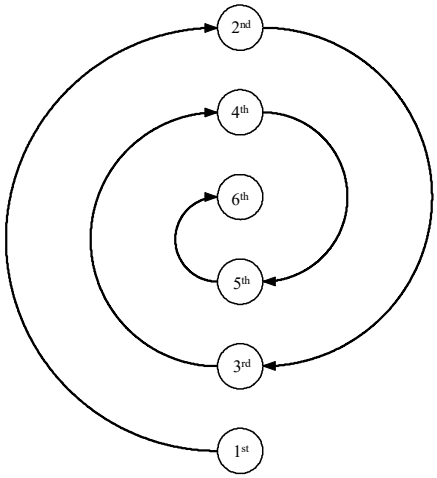


**Figure 1:** *Spiral pattern of the sestina.*

## Sestina Music, the Septina and Beyond

The spiral pattern shown in Figure 1 is somewhat audible when reading a sestina aloud. In particular, the transition between stanzas draws our attention, because the word that ends one stanza echoes soon after in the first line of the next. However, one can argue that the best way to hear the sestina pattern is in music.

Lisa Lajeunesse composed *Sestina Music* (see [7]) to illustrate this pattern. It is based on a simple ascending sequence of 6 notes in C major: C D E F G A. These notes act like the 6 repeating words in a sestina. The music is shaped by this note sequence, as the notes are permuted to produce five more sequences. Each 6-note sequence forms a musical phrase that is analogous to one stanza of a sestina.

In the recording, the first two phrases (the equivalent of the first two stanzas) are heard in the bass (lower register) without any accompanying harmonies. This is to highlight the pattern of the sestina permutation for the listener as the music transitions from the first phrase to the next. Once this is established, the music returns to the beginning and repeats the 1st phrase, but this time the bass notes are also the names (or roots) of the chords that are added to the treble (higher register) to accompany the bass line. Thus, we hear $2 + 6 = 8$ phrases in total:

$$\underbrace{1,2}_{\substack{bass\ line \\ only}}\ ,\underbrace{1,2,3,4,5,6}_{\substack{bass\ line\ with \\ chords}}$$

When the first phrase is repeated, the accompanying 6-chord sequence: *C d e F G a* is added. The upper case letters refer to major chords, while the lower case refer to minor chords. Table 2 shows the bass note (also chord sequence) pattern for each phrase.

**Table 2:** *Note and chord sequence in Lisa Lajeunesse's "Sestina Music."*

| Phrase 1 | Phrase 2 | Phrase 3 | Phrase 4 | Phrase 5 | Phrase 6 |
|---|---|---|---|---|---|
| C | a | e | G | F | d |
| d | C | a | e | G | F |
| e | G | F | d | C | a |
| F | d | C | a | e | G |
| G | F | d | C | a | e |
| a | e | G | F | d | C |

Of course, anyone interested in composing sestina-like music can vary the initial 6 notes that generate the musical pattern, just as a poet writing a sestina is free to choose any six words to end the lines of the poem. While composition of sestina music will not be part of the workshop discussion, we will play the brief musical excerpt for participants. We hope that hearing the music will broaden participants' experience of the sestina by giving them an alternative, auditory perspective on its permutation pattern.

Jacques Roubaud of the French literary group Oulipo adapted the sestina's spiral pattern to create a septina [8] based on $n = 7$. The septina introduces a seventh word and a seventh stanza. Unfortunately, the permutation that strictly follows the spiraling pattern does not produce a 7-cycle. The permutation obtained from the spiral pattern is $\sigma = (1247)(36)(5)$. This leads to a number of un-sestina-like effects. The 1st, 2nd, 4th and 7th words form a 4-cycle. The words in lines 3 and 6 form a 2-cycle (swapping positions from one stanza to the next), and the last word of line 5 remains fixed throughout. Roubaud was able to mitigate these problems by adapting the pattern and using only six lines in each stanza. Thus, each stanza is missing one of the 7 words. Oulipian Harry Mathews' septina *Safety in Numbers* can be found at [9] as an example of this form.

Roubaud and mathematicians who followed investigated the question: for what values of *n* (other than $n = 6$) does a sestina-like permutation lead to a cycle on *n* elements? The result is surprisingly complex. A simple investigation of the positive integers between 3 and 12 leads to success with numbers 3, 5, 6, 9 and 11 only. The interested reader can learn more about why some numbers work and others do not in [10].

## The Golden Shovel

The Golden Shovel is a new poetic form created by Terrance Hayes in honor of Gwendolyn Brooks [5]. The last word of each line in a Golden Shovel is taken in order from a line of the writer the poet is honoring. The results can be quite different from the original poem. It shares something with the cento or the erasure, in incorporating another writer's words into the poem. In the Golden Shovel the effect is additive as the poet brings their own words into dialogue with the words of the writer to whom they are paying tribute.

The Golden Shovel provides the poet with two unique opportunities. First, as discussed in the explanation of its construction, it can serve as homage to another scholar. Because the writer of the originating text can come from any realm, the chain of end words in the Golden Shovel is a way to incorporate the work of other mathematicians into our poetry. Secondly, the form presents an interesting challenge in terms of creating line breaks.

Where to break the line is a central conundrum in writing poetry. Poets use a variety of techniques to create line breaks. Historically, the primary method was to count the stresses in a line. For example in the line "The rain in Spain falls mainly on the plain," there are 10 syllables, and 5 stressed words (rain, Spain, main, on, plain). This particular pattern is one of the most common in English and is called iambic pentameter. There are many other syllabic patterns. In contemporary English verse, many poets count stresses, or syllables in constructing line lengths, but few use rigid patterns such as iambic pentameter. Another common practice is to insert line breaks at the end of an important thought or word. This is illustrated in Chana Bloch's poem *At the Border* [1].

*At the Border* by Chana Bloch
(for Nina)

My hand slips past the guardrail
of the hospital bed,

date of birth on my wristband,
date of death postponed.

By the grace
of a scalpel blade

I have made it across
the border just

in time. My blessing hand rests
on Nina’s great naked belly,

Liliana treading water,
headed for land,

her millions of eggs
already alive inside.

In this poem, each line ends either on a grammatical unit such as *headed for land*, or an important word such as *guardrail.* This technique allows the reader a moment to pause before going on to the next unit of thought.

In contrast, the Golden Shovel relies on the technique of using each word of the original quote as the last word of the line. In the poem, *Ask For A Universe* shown below, Dorf uses a quote about dark matter

by astronomer and cosmologist Beatrice Tinsley [4]. The full abstract from a paper on which Tinsley is a co-author reads

> *A variety of arguments suggest that the density of the universe is no more than a tenth of the value required for closure. Loopholes in this reasoning may exist, but if so, they are primordial and invisible, or perhaps just black*.

The words of the second line from the abstract become the last words in the lines of the Golden Shovel. They are shown in bold below for the purpose of this discussion. The form facilitates the discussion of an idea with someone one may or may not know in real life, as the poet was able to reflect on in [2].

*Ask for a universe and what do you get?* by Carol Dorf
(a Golden Shovel for Beatrice Tinsley)

For a while scientists' proposed **loopholes**
crossing the universe, wormholes a technique **in**
which to traverse distance to other worlds, **this**

unpleasant constraint which most **reasoning**
holds us to a single solar system or **may**
be, just perhaps a transit could **exist**

to get us to Proxima Centauri **but**
travelling 4.25 light years is a big **if –**
human tolerance of forces matter – **so**

most likely our AI will proceed us and **they**
will send back slow data just to say *We **are***
*fine and happy in the **primordial***

*reaches of space making the **invisible***
*visible while we observe expansion* – **or**
it is possible we will forget them **perhaps**

because the heat becomes unbearable or maybe **just**
because too close to light we lose night's **black**.

## Summary and Conclusions

The sestina and Golden Shovel offer an ideal opportunity to combine mathematics with poetry. The sestina has a mathematical permutation at the heart of its form. The Golden Shovel provides an opportunity to pay homage to a mathematician or a mathematical idea through poetry. The sestina, an ancient form, may seem likely to contrast the modern form of the Golden Shovel. However, when placed side-by-side in this workshop, the similarity between these forms will appear in relief. By fixing the last word of each line and constraining the poet's choices in the same way, writing poetry in each of these forms becomes a strikingly similar experience.

Participants in this workshop will not only have the opportunity to learn about two poetic forms, but also experience the poetic forms first-hand by writing a sestina and a Golden Shovel of their own. They will also have the opportunity to share their poetry with one another. Educators who would like to introduce their own students to the sestina or Golden Shovel forms can easily reproduce the structure of the workshop and the materials used in their own classrooms. Both groups will see first-hand how fixing the last words of each line in a poem can help lead the poet to the poem.

## References


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