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The Space & Geometry of Sioux Tipis

Ask any American elementary-schooler what a tipi is and they will probably be able to tell you. In a country that extensively and intentionally erases Native history in the classroom, the tipi is one of the few symbols that makes it through. It's simple! It's romantic! It's basically a tent, but cooler, right? In reality, the tipi is an efficient portable dwelling, simultaneously decorative and practical, carrying both literal and symbolic importance in the cultures who developed, defined, and utilized it. In this paper I will explore the tipi through an ethnomathematical lens, examining the geometry and engineering behind its construction, the spatial arrangements in its use, and the practical and cultural significance behind these aspects of this iconic dwelling.

Background & Development

The tipi in its various forms was developed and used by several Nations, including the Sioux, Crow, Cheyenne, Blackfeet, and Arapaho, living in the plains east of the Rocky Mountains in what is now the midwestern U.S. and southern parts of Canada. The word "tipi" comes from the Sioux and translates as "used to dwell". The main value of the tipi is its versatility as a shelter functional in all weather, while being easily portable in order to follow herds of buffalo around the plains. Tipis were originally transported by dogs, but when horses were introduced in the seventeenth century, their ability to carry larger and heavier loads allowed tipis to double in size. The Sioux tipi is perhaps the best known of all tipi variations and will be the focus of the rest of this paper.[1]

[1] Nabokov & Easton, *Native American architecture*, p. 123-4

Spatial Patterns in the Tipi and in Sioux Culture

The main geometric figure that characterizes the tipi is a circle. When set up, it forms a cone with a nearly circular base; when the cover is laid flat, it essentially forms a semicircle. Additionally, when a tribe sets up their camp, the tipis are all arranged in a larger circle. Even in larger gatherings, tipis are set up in a circle, sometimes more than one layer deep, with sections belonging to each smaller tribe. Whenever a group of people gather for a ceremony, they likewise sit in a circle. The circle is not just a practical or aesthetic choice but also carries significant symbolic meaning. The Sioux draw connections between many circular objects that appear in nature, such as the dome of the sky, a bird's nest, the sun, the earth, and the moon. They also observed natural cycles of time, connecting the cyclic patterns of days, years, and the sun's and moon's arcs through the sky.[2]

Nearly as prominent as the circle motif is a strong sense of the four cardinal directions, each of which has a symbolic meaning. The west is associated with death, while the east signifies life. The north and south respectively represent the sky and the earth. This division between sky and earth was related to a division between male and female: when a mixed-gender group gathered in a tipi, men sat on the north side and women on the south.[3] Tipis were also always set up with the door facing east, which served the practical goals of utilizing the light and warmth of the rising sun and sheltering the occupants from the wind that frequently came from the west. Circles of tipis were also always organized with the opening to the east, indicating that this strong sense of directionality extends beyond purely practical concerns.[4]

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[2] Nabokov & Easton, *Native American architecture*, p. 125
[3] Nabokov & Easton, *Native American architecture*, p. 162-3
[4] Laubin & Laubin, *The Indian Tipi*, p. 46

Within the tipi, the layout also remained constant and prescribed. The fire was always built in the center, under the smoke hole, with an altar next to and behind (west) of it. The three sides not near the door held sleeping mats, and the oldest male occupant slept in the back. The area near the door held supplies like cooking equipment and firewood.[5] This arrangement is certainly practical: intuitively, it is safer for people to sleep farther from the doorway, and a central fire provides heat evenly to all the occupants. However, its consistency across different families and tribes indicates some shared cultural values, such as the importance of cardinal directions and precision and care in setting up the household.

Geometry of the Tipi Structure

To examine the geometry of a tipi, we model it as a cone. In fact, a tipi is not a perfectly symmetrical right cone. If the tipi were set up as a right cone, the intersection of all the poles would be vertically above the fire, which is always in the center of the tipi floor. The smoke hole, however, is set in front of the intersection point of the poles, which is also the point of our theoretical cone. Naturally, the smoke hole needs to be above the fire. In practice, tipis are set up as oblique cones, with the point set farther toward the back of the tipi, leaving the smoke hole directly above the fire. This design gives the tipi a steeper back and a more gradual slope toward the door.[6] In practice, the floor of a tipi is not a perfect circle either, but somewhat of a squat egg shape, with the wide end toward the steeper back side of the tipi.[7] The exact floor plan of course can vary depending on how the people setting up the tipi choose to place each of the poles, and the

[5] Nabokov & Easton, *Native American architecture*, p. 156
[6] Laubin & Laubin, *The Indian Tipi*, p. 60
[7] Nabokov & Easton, *Native American architecture*, p. 150

base is close enough to circular that it makes sense, for the purpose of geometric analysis, to model the tipi as a cone with a perfectly circular base.

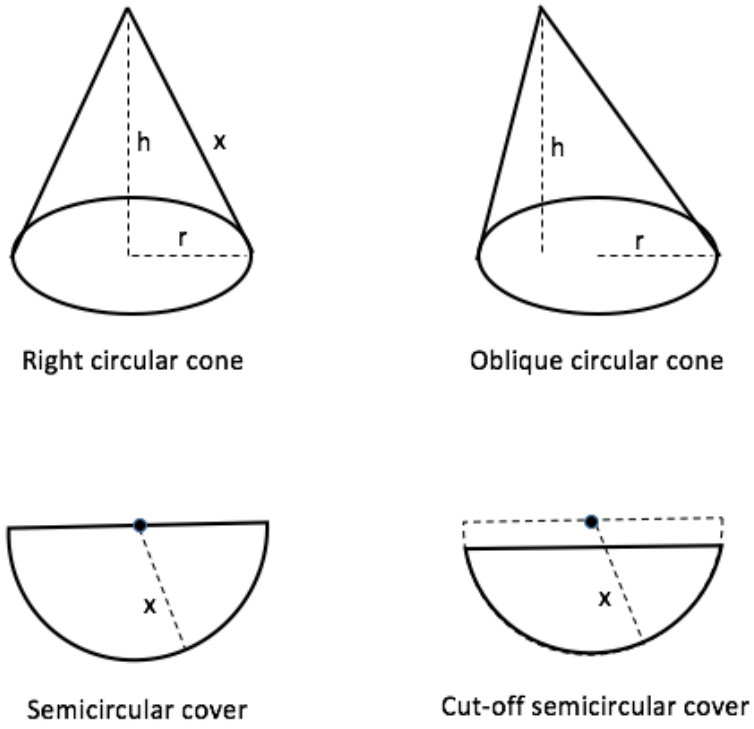

Figure 1

If the tipi were a perfect right cone, it would require a semicircular cover. The lateral surface area of a cone is equivalent to some portion of a flat circle, with the full 360 degrees representing a cone with infinite radius, a very small arc, perhaps 30 degrees, resulting in a sharp cone with a tiny radius, and a cone whose radius, height, and slant height form a 30-60-90 triangle is formed from half a circle. We can confirm this measurement by calculating the area of a

semicircle and the lateral surface area of a cone with the ratio x = 2r and verify that they are equivalent:[8]

$$LSA_{cone} = \pi r x = \pi r(2r) = 2\pi r^2$$

$$A_{semicircle} = \frac{1}{2}\pi x^2 = \frac{1}{2}\pi(2r)^2 = \frac{1}{2}\pi * 4r^2 = 2\pi r^2$$

This ratio where the radius of the cover equals the diameter of the finished tipi comes from an observation by the authors of *The Indian Tipi* and confirmed by the above equations. Laubin and Laubin do not give a reason or origin for this sizing, but it appears to be practical as a balance between height and floor area, visually appealing, and easy to visualize as the result of wrapping a semicircle around a frame. Perhaps this design developed from older, less optimal models, or perhaps early tipi architects started with a half circle and never found a reason to greatly modify it.

Extending this analysis of a right cone, we turn to the more accurate model, an oblique cone maintaining the same x=2r ratio as above. The cover for this cone, which turns out to also be the cover for a real tipi, is essentially a half circle with a slice taken from it, or a half circle whose center point is shifted out from its widest edge (see Figure 1). The farther out one shifts the radius point, the farther the point of the cone moves laterally away from the center of the base.

Construction, Engineering, and Weather Modifications

In examining the tipi as an example of ethnomathematics, we may also ask what innovations of engineering grew out of the necessity to construct a functional dwelling. Three main

[8] Cone terminology and area formulae drawn from Wikipedia; analysis and Figure 1 are my own work

issues arise when weather comes into the equation: how to stay cool enough in summer, how to stay warm enough in winter, and how to stay dry when it rains.

Summer is perhaps the easiest problem to tackle. The cover of the tipi, made from buffalo hides, provided shade, and the bottom edge of it could be propped up to catch a breeze, easily cooling the interior. In cold weather, the fire played a major role in warming the tipi, but significant insulation came from the inner lining, or dew cloth, another piece of buffalo hide hung on the inside of the poles from about 5 feet high to the floor. The air trapped between this lining and the outer cover insulated the tipi, but in extremely cold weather when simple air did not suffice, the space could be packed with grass. [9]

This dew cloth, as hinted at by its name, also played an important role in dealing with moisture. Rain running into the tipi was unavoidable as the same poles lining the interior extend above the leather cover. Water that fell on the tops of the poles would naturally want to run down along their length. To prevent this water from dripping, selecting poles that were straight and smooth, without bumps or knots, was standard. If water dripped from the lower part of the poles, the dew cloth would prevent it from dripping on the sleeping occupants. The outer hide of course was naturally waterproof enough to keep rain from soaking through it, but would also be tanned and smoked to ensure that repeated exposure to moisture would not deteriorate the leather.[10]

Another remarkable engineering feat is that the tipi is fairly simple to assemble. All variations on the tipi design have a base of either three or four poles; the Sioux tipi uses three.[11] These base poles, generally the three heaviest, are tied together and set up as a tripod, arranged so that the poles lock against one another and can support the rest of the poles, which are set with

[9] Nabokov & Easton, *Native American architecture*, p. 156
[10] Nabokov & Easton, *Native American architecture*, p. 156
[11] Nabokov & Easton, *Native American architecture*, p. 152

their wide ends arranged around the base of the tipi and the tops resting in one of the crotches between two tripod poles. Raising this tripod only requires two people, one to lift the poles and one to brace the rope that ties them together. A moderately sized tipi requires about 15 poles: the original three to form the tripod, and four in each segment between them. The final pole, called the lifting pole and located at the back of the tipi, has the cover attached to it and is used to lift the cover into place.[12]

With the precise design of a tipi and its relatively simple components, this portable tent functions very effectively as a climate-controlled dwelling, easy to set up and take down but comfortable to live in. The design perfectly fits the purposes of the tipi, and demonstrates innovation and adaptability on the part of the people who developed it.

Who is the Tipi for?

In examining the cultural context of the tipi, it becomes clear that there is a gap between the work behind a tipi and its symbolic meaning. A tipi is the property, essentially, of the most prominent man living in it. The outer decorations painted on the cover refer to him, depicting either his victorious exploits in warfare or sacred symbols relating to dreams had by him or by his ancestors.[13] However, the construction of the tipi, from sewing the hides together, treating them, calculating the size to make the cover and lining, maintaining the component parts, and setting up and taking down the tipi are all traditionally the job of the woman (or women) who live in it.[14]

This gender difference is indicative of the gender dynamics in the general Sioux society. One of the major cultural values is bearing children, so much so that women view motherhood as

[12] Laubin & Laubin, *The Indian Tipi*, p. 45-49
[13] Nabokov & Easton, *Native American architecture*, p. 165
[14] Laubin & Laubin, *The Indian Tipi*, p. 43

an unescapable reality. The women's domain is very much within the household, and as much as achievements for men in hunting and war are emphasized, crafts are equally important skills for women to master. A cradle, the crowning achievement in crafting and generally gifted to a female relative, is as valuable as a horse. This ties in to the qualities associated with north and south mentioned earlier, where women are associated with the earth and men with the sky. Men's domain includes broader concerns such as more religious aspects of life, while women are connected to the earth, to constructing objects from physical materials, and running a home.[15] It makes sense within this context that the tipi, while visually and symbolically a status symbol for the man, is the domain of, and result of hard work by, a woman.

What Makes a Tipi Ethnomathematics?

We have examined tipis from several angles, some of them mathematical, some of them cultural. But are tipis an example of ethnomathematics? They certainly arose from cultural necessity: the need for shelter, at the most basic level, but particularly the need for a shelter adaptable to both hot and cold temperatures that is simultaneously portable due to the need to follow herds of buffalo. I have demonstrated that the structure of a tipi involves geometry, and even without the formal math, some conceptual understanding of the shapes is necessary to successfully build a conical tipi from a flat piece of cloth. I have explored the cultural significance of the circle, a geometric figure, and its connections to natural objects and cycles of time that demonstrate implicitly mathematical thought. The engineering and spatial relationships present in tipis are excellent examples of mathematical ideas realized through aspects of culture and daily life of the Sioux people.

[15] Hassrick, *The Sioux: Life and Customs*, chapter 2, p. 41-2

The Cultural Importance of the Tipi in Modern Times

To conclude, it is important to consider the Sioux not only as a historical people, during what may be considered their golden age, but also as a modern nation, struggling with the effects of colonization. For example, the Oglala Sioux in the past few decades have been organizing to establish more self-governance as a nation, in keeping with Lakota culture. The CIRCLE project is one initiative based around reforming the justice system and law enforcement to reflect their cultural community values and needs. CIRCLE, which stands for "Comprehensive Indian Resources for Community and Law Enforcement," shows the ongoing importance of circles in Sioux culture, reflected in this clever choice of acronym.[16] One part of this project involves phrases that connect the efforts to cultural values, one of which is "raising the tipi." This phrase captures themes of home, family, shelter, teaching, and community living.[17]

These snapshots of a modern project show the ongoing importance of the tipi and the circle as cultural symbols and aids to community building and decolonization efforts.

[16] Robertson, Jorgensen, & Garrow, *Indigenizing Evaluation Research*, p. 499-500
[17] Robertson, Jorgensen, & Garrow, *Indigenizing Evaluation Research*, p. 506-7

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The Sioux tipi, with its beauty of line and practical design, is a shining example of the structure that was home to the buffalo hunters of the Great Plains. The Sioux lived in a large area of the Great Plains stretching from what is now central South Dakota and Nebraska through Wyoming and Montana and into the Canadian provinces of Alberta, Saskatchewan, and Manitoba. In the summer, they camped on the open plains, choosing campsites with lots of firewood, water, and grass nearby. In winter, when the weather was cold and harsh, the Sioux camped in sheltered places and pitched their tipis where it was convenient, rather than in a particular pattern as they did in the summer. Some of their favorite campsites were among the tall trees of the Black Hills. The Sioux, one of the largest and strongest Native American tribes, are a confederacy of several tribes that speak three different dialects.Â Siouan Language Group of Native Americans. Fort Laramie Treaty. Myths & Legends of the Sioux. Sioux Indian Wars. Sioux Photo Gallery. The Sioux are a confederacy of several tribes that speak three different dialects, the Lakota, Dakota, and Nakota. The Lakota, also called the Teton Sioux, are comprised of seven tribal bands and are the largest and most western of the three groups, occupying lands in both North and South Dakota. The Dakota, or Santee Sioux, live mostly in Minnesota and Nebraska, while the smallest of the three, the Nakota, primarily reside in South Dakota, North Dakota, and Montana. The phase space geometry of the metric Hamiltonian $H_g(x,p)=g^{ab}(x)p_ap_b$ and the phase space geometry of the first order q-de Sitter dispersion relation of the form $H_{qDS}(x,p)=g^{ab}(x)p_ap_b + \ell G^{abc}(x)p_ap_bp_c$ which is suggested from quantum gravity. phenomenology. We will see that for the metric Hamiltonian H_g the geometry of phase space is equivalent to the standard metric spacetime geometry from general relativity. For the q-de Sitter Hamiltonian H_{qDS} the Hamilton equations of motion for point particles do not become autoparallels but contain a force term, the momentum space part of phase space is curved and the curvature of spacetime becomes momentum dependent. Discover the world's research. 20+ million members. The Tipi and Plains Indians: Functional Housing and Community Development â€” Steemit. The tipi has been misrepresented as a universal symbol of indigenous architecture, but it was the Plains Indians whoâ€¦ by folke. Article by Bob. 81.Â Sioux Tipi - Shelter - Historical Cultural Studies, Tiburon/Belvedere, CA | Telli. Andi Miles Survival stuff. rÃ©alisations de bois rond, charpenterie et autres projets | Harkins.ca. Geometry in flashcards yay!!! Learn with flashcards, games and more â€” for free.Â Let there be a set called space, of elements, called points, with points, lines, and planes being subsets thereof, so that the following axioms are satisfied. This set is often saved in the same folder as Propositions for Quizzes (Updated Proposition 11).