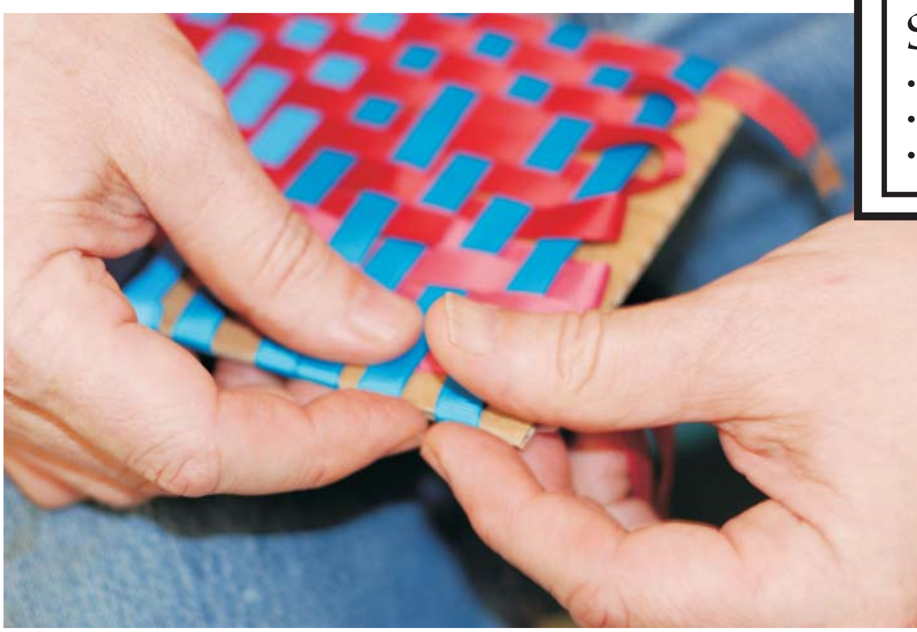
COMPONENT 1: HAND-HELD

This component entails the creation of a weave on a piece of corrugated or solid, heavy card, using 3/8” ribbon. The weaver produces two patterns, consecutively.

- Choose a piece of cardboard, and two colours of 3/8” ribbon.
- Wrap the first ribbon lengthwise on the cardboard so that one face is completely covered, with small gaps between the strands. Tape the ends, both on the same face. This is your **warp**. Flip the card to weave on the untaped side.
- On the untaped face, weave the second ribbon through the warp, first by alternating over-and-under to create plain weave. When you reach the last warp on the edge, flip the ribbon and create a **re-entry** point, starting the next row. The edge that is created by these re-entries is called a selvage or **selvage** or (self-edge). If you ended the first row with an “under”, be sure to start the next with “over” or the weave will unravel.
- Cover about half of the card. This is **plain weave**.
- Continue weaving, but this time weave over 2, under 1, over 2, under 1, etc. until you are across.
- For the next row, weave the same way, but make sure the “under” is shifted by one warp.
- continue as before, shifting the position of the “under” across the weave. This is ½ (”one-two”) **twill.**

SUPPLIES:

- 6”x8” cardboard rectangles
- 3/8” ribbon (2 colours)
- Masking tape



Problem Posing

Can you think of another pattern to try?

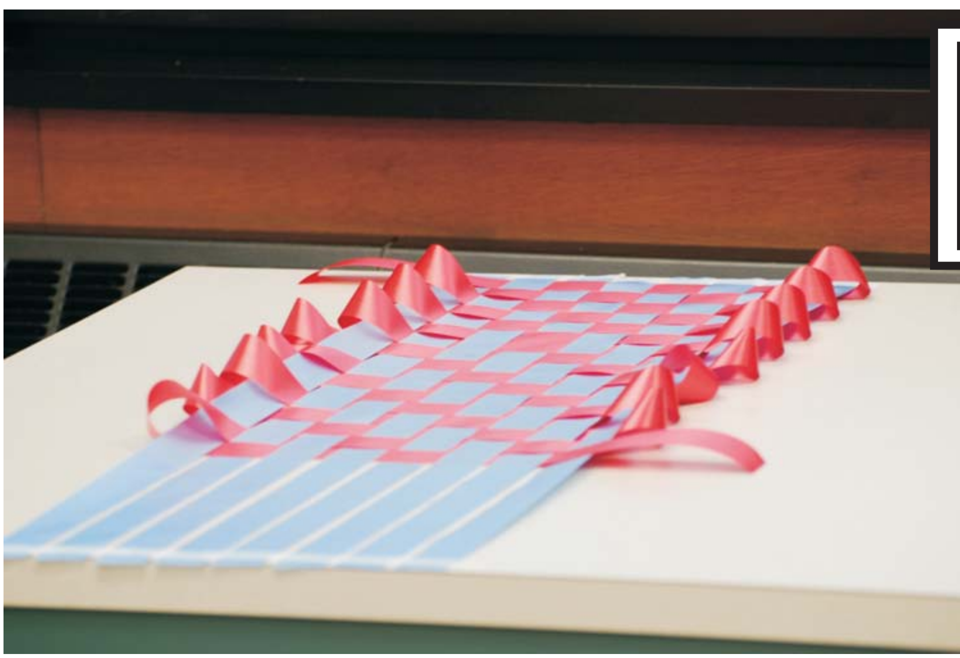
Can you predict what number patterns would produce interesting weaves?

How do the changes affect the strength or stability of the weave?

COMPONENT 2: TABLE TOP

This component entails the creation of a table-top weave , using 3/8” ribbon. The weaver produces two patterns, consecutively.

- Choose a large table, and two colours of 7/8” ribbon.
- Cut the first ribbon into 8-10 strips that are the same length as the width of the table (this was done in advance for the workshop). Lay the strips on the table width-wise, leaving small gaps. Tape both ends down so that the ribbons are taut. This is your warp.
- Weave through the warp, using the second ribbon, by alternating over-and-under: this creates **plain weave**. When you reach the last warp on the edge, flip the ribbon and create a **re-entry** point, starting the next row. The edge that is created by these re-entries is called a selvage or **selvedge** (self-edge). If you ended the first row with an “under”, be sure to start the next with “over” or the weave will unravel.
- Cover about half the length of the warps.
- Continue weaving, but this time weave over 2, under 1, over 2, under 1, etc. until you are across. For the next row, weave the same way, but make sure the “under” is shifted by one warp. Continue as before, shifting the position of the “under” across the weave. This is ½ (”one-two”) **twill.**



SUPPLIES:

- Large table
- 7/8” ribbon (2 colours)
- Masking tape

Problem Posing

Can you think of another pattern to try?

Can you predict what number patterns would produce interesting weaves?

How do the changes affect the strength or stability of the weave?

Weaving Glossary

Interlacement: The arrangement or structure of crossed threads in a woven cloth.

Plain weave: The most basic weaving method, and interlacement, in which each thread passes alternately over and under the threads at right angles to itself [over 1, under 1].

Re-entry: The act of turning a *weft* element around before re using it in the next *shed.*

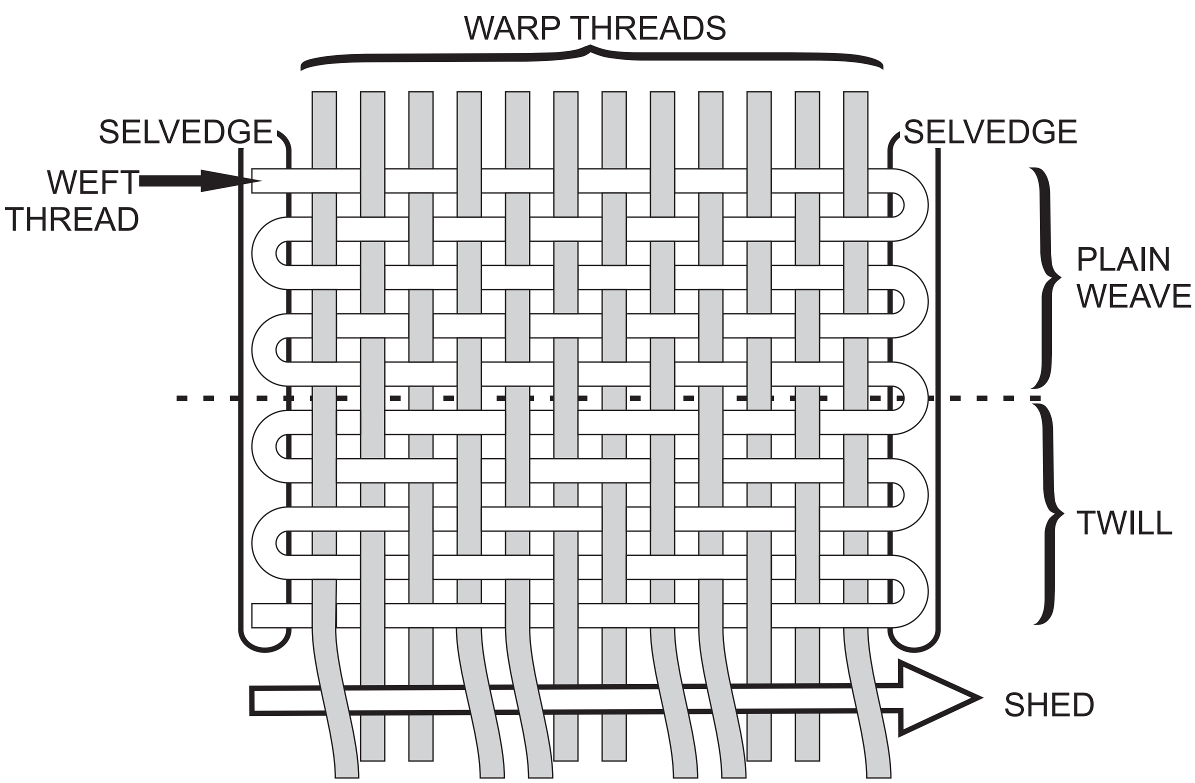
Selvage or selvedge: The edge of a piece of woven material, parallel to the warp threads, where the weft enters, exits, turns, and re-enters the interlacement.

Shed: The opening made between the threads of the warp by the motion of some of the warp ends up and others down, through which the weft or the shuttle carrying the weft is passed.

Twill: A woven fabric characterized by parallel diagonal pattern lines, produced when the weft threads pass over one or more, and under two or more, threads of the warp, and the pattern shifts by 1 warp end with each successive weft thread.

Warp: The threads which are extended lengthwise in the loom, usually twisted harder than the weft or woof, with which these threads are crossed to form the web or piece.

Weft: The threads that cross from side to side of a web, at right angles to the warp threads with which they are interlaced.



Modular Systems

What do the numbers 7, 11, 15, 19 and 23 have in common?

- They can each be written in the form $4k+3$ for some integer k
- They each have the same remainder when divided by 4
- If we add any two of them together, we get an integer of the form $4k+2$ (ex. $7+15=22=4(5)+2$)
- If we find the difference of any two of them, we get an integer that is of the form $4k$ (ex. $19-7=12=4(3)$)

These numbers are said to be in the same modulus class for modulus equal to 4.

Modular systems are mathematical systems that can be useful for many applications that involve cyclical changes. Many cycles arise in day-to-day life. For example, the 12-hour clock has modulus equal to 12. To determine what time it is 8 hours after 10 o'clock, we add 8+10 to get 18. Then 18=12+6, so it would be 6 o'clock. Similarly, 88 hours after 10 o'clock would be 2 o'clock because 88+10=98=8(12)+2.

Another common example is the 7-day week. If today is Tuesday, then we know that in 22 days it will be Wednesday because 22=7(3)+1, so we are one day past Tuesday.

The relation congruence modulo m (or just *mod m*) is defined for integers by $a \equiv b (\text{mod } m) \leftrightarrow a, b$ have the same remainder when divided by m.

Thus, $98 \equiv 2(\text{mod } 12)$ and $22 \equiv 1(\text{mod } 7)$.

Addition in modular systems obey the rule:

- If $a \equiv b(\text{mod } m)$ and $c \equiv d(\text{mod } m)$, then $a+c \equiv b+d(\text{mod } m)$.

For a modulus of 4, the possible remainders are 0 ,1, 2 and 3.

Addition table *mod* 4

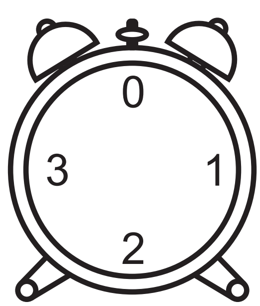
	0	**1**	**2**	**3**
0	0	1	2	3
1	1	2	3	0
2	2	3	0	1
3	3	0	1	2

The table to the right summarizes what happens to remainders. For example, the remainder of 14+23 is 1 because 14+23=37=4(9)+1 but also because the remainder of 14 is 2, the remainder of 23 is 3, and 2+3=5 which has a remainder of 1.

From the table, a few observations can be made:

- The table has **closure:** the only possible entries are 0, 1, 2 and 3
- The addition operation is **associative**: $a+(b+c)=(a+b)+c$
- 0 is the **identity element**: an element that doesn't change other elements
- Each element has an **inverse:** a way to get back to 0; for example, the inverse of 3 is 1

The set {0,1,2,3}, together with addition *mod* 4 forms a mathematical system known as a group. It is a cyclical group and a 4-hour clock can be used to visualize it.



Component 3: Whole Group

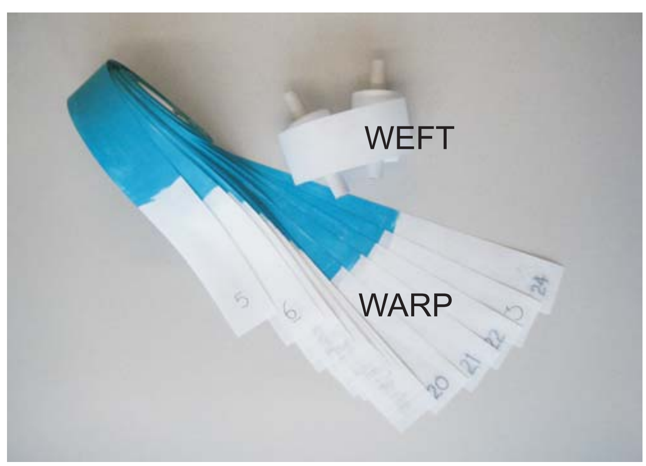
Supplies:
- Two 100-yard rolls of 4” curtain interfacing
- 2 pints household acrylic Paint
- Permanent Marker

Preparation

- Cut 20 lengths of interfacing at 3 yards each. These will be your **warps**.
- Mark off 12” from each end with a transversal line: these sections will not be painted.
- Paint the area between the marks using household acrylic paint.
- Mark the two ends of each strip with the same number, counting consecutively from 5 to 24.
- Stitch the remainder of the first roll onto the end of the second roll. This will be your **weft**.
- Roll it onto two empty toilet paper rolls so that both rolls contain about half of the strip.

Activity

- Line up two rows of 10 participants, facing each other, almost rubbing shoulders. These are the warp lifters.
- Distribute the warp strips so that each pair of facing warp lifters holds two strips in parallel. The strips should be in consecutive order and taut without risking them slipping out of hands, as horizontal as possible, and approximately at 4 feet high.
- Consider the numbers on the strips. If you divide the number by 4, what is your remainder?
- Remember the remainders for your two strips.
- Practice lifting:
    1. everyone lift strips with a remainder (**mod 4**) of 1 (every fourth strip should be lifted, starting with #5); everyone lift strips with a remainder (**mod 4**) of 2 (every fourth strip should be lifted, starting with #6);
    2. everyone lift strips with a remainder (**mod 4**) of **0** ***or*** **2** (every second strip should be lifted, starting with #6);
    3. try other combinations of remainders.
- Because both rows of warp lifters will lift and lower warp strips, the weaving will start in the middle and move outward towards the lifters.
    1. The caller asks the warp lifters to lift the strips with an **odd** number on them (also **1 or 3 mod 4**). This should lift every second strip. It produces the first **shed**.
    2. The weaver(s) pass one roll through the shed, so that there is now a roll at each end.
    3. The caller asks the lifters to lower the **odd** strips and raise the **even** strips (also **0 or 2 mod 4**).
    4. The weavers pass the rolls back, one on each side of the first woven strip.
    5. Continue to call, raise and pass through, alternating between the **odd** and **even** strips, for 3 or 4 more runs. This produces **plain weave**.
- Switch to calling for and weaving **twill**:
    1. Lifters, lift strips whose number yields a remainder of **1 or 2 mod 4**; weavers weave through on both sides.
    2. Lifters, lift strips whose number yields a remainder of **2 or 3 mod 4**; weavers weave through on both sides.
    3. Lifters, lift strips whose number yields a remainder of **3 or 0 mod 4**; weavers weave through on both sides.
    4. Lifters, lift strips whose number yields a remainder of **0 or 1 mod 4**; weavers weave through on both sides. Go back to 1 in **twill**.



Key Discussion Points

- What did you focus on at the different scales,
  a) mathematically,
  b) aesthetically
  c) experientially
  — did this stay the same or change?

- What mathematical relationships did you notice most clearly at:
  a) smallest scale
  b) medium scale
  c) largest scale

- Did you rely on knowledge of mathematical pattern to help you to better understand or accurately complete the weaving pattern? What were they?

- Did the experience of weaving help you to see or to see better any mathematical ideas or patterns? What are they?

- We used scaling up for weaving — where else might scaling up (or down) help students gain insight into a mathematical/artistic process?

- As we weave, we considered many materials — what other materials might you weave with, how might it change what happens?

- Could you make a diagram or drawing of weaving? what would it look like? Would it be art all by itself? What essential aspect of weaving would need to be integrated?

- Could you set the large scale weaving to music? How and what music? What would it look/sound like?

- The idea of ‘edge', is a big idea in weaving, in math and in other forms of art. How might you explore the idea of ‘edge’ and ‘edges’?

- What specific ways could you use scaling up to illustrate math concepts or get students to apply math concepts?

- Can you think of other ways in which a full-body activity can help to understand a mathematical concept?

- What other options did this experience suggest to you for future exploration? In weaving? In some other concrete form?

- Consider the statement: Weaving (and art) is about changing variables and controlling them- how could this idea help students to understand the relevance of math in their everyday lives?