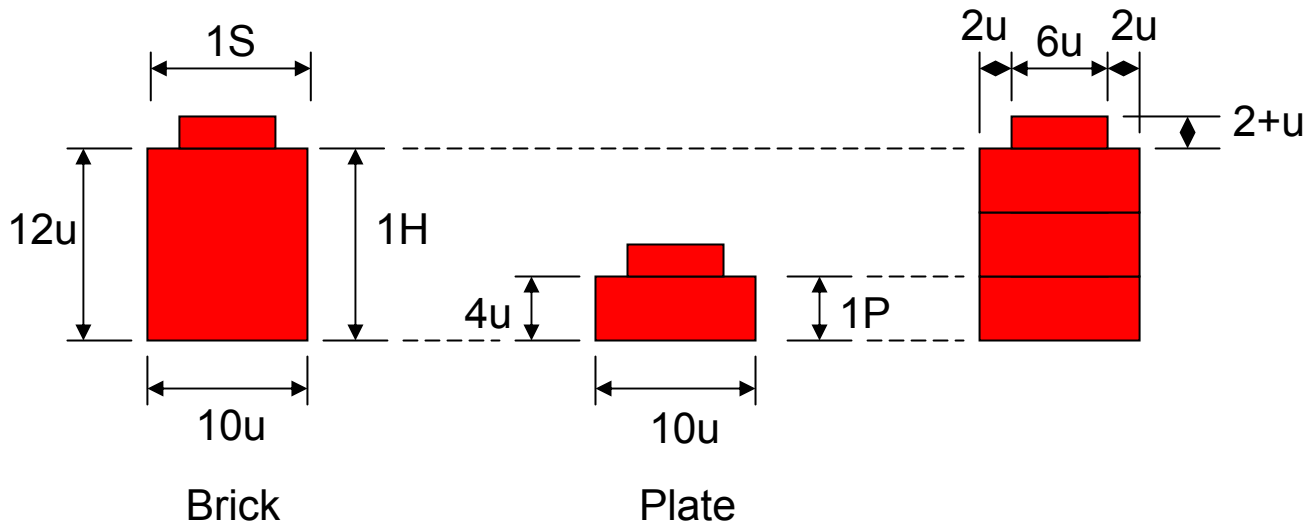
Basic Geometries

U = Unit
S = Stud (Unit of Width)
H = Brick Height (Unit of Height) (1)
P = Plate Height



1S =	1 Stud Width	= 5/6 Brick Height	= 5/2 Plate Height	= 10 units
1H =	6/5 Stud Width	= 1 Brick Height	= 3 Plate Height	= 12 units
1P =	2/5 Stud Width	= 1/3 BrickHeight	= 1 Plate Height	= 4 units

(1) I don't use B for Brick Height because its too ambiguous I find That I confuse it with 'Brick Width' Which is also a term I use as Synonymous with Stud.

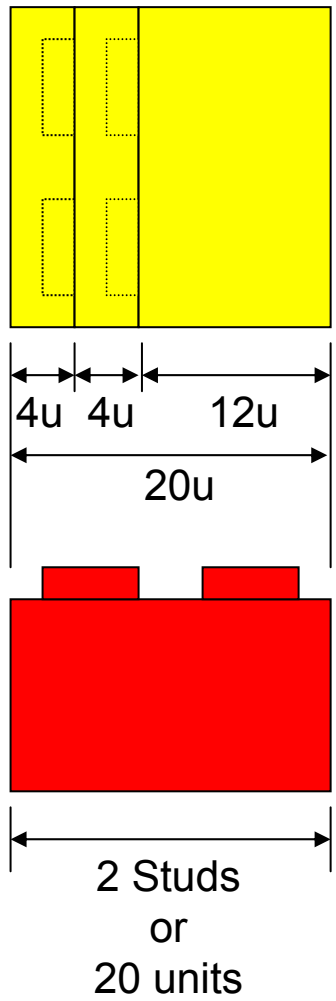
Stud Width to Brick Height: Even

You can always find a ‘Brick Height’ equivalent for any **even** number of studs. For example:

2 Studs = 2 Studs * (10 uints/Stud) = 20 units
= 20 units / (4 units/ Plate) = 5 Plates
= 1 Brick & 2 Plates

But, the top ‘Plate’ must really be a tile, since the studs stick up an extra 2 units. Therefore, the equivalent of 2 studs, in brick heights is:

2 Studs = ! Brick, 1 Plate & 1 Tile



Stud Width to Brick Height: Odd

You can also find a near ‘Brick Height’ equivalent for any **odd** number of studs. It is a snug fit and it leaves gaps due to the studs.

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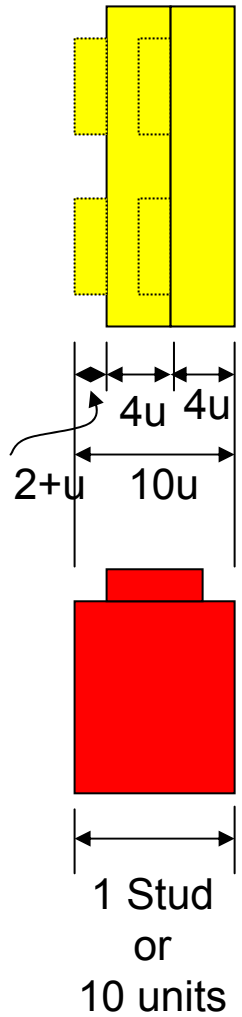
For example:

1 Studs = 1 Studs * (10 uints/Stud) = 10 units
= 10 units / (4 units/ Plate) = 2 Plates + 2 Units

The height of the studs are ~2.5 units. Therefore 2 plates, plus the stud height of the top plate, make about 10 units, or exactly Stud Width.



Brick Height to Stud Equvilances

Even Number of Studs

2 Studs = 1 Brick, 1 Plate, 1 Tile
4 Studs = 3 Bricks, 1 Tile
6 Studs = 4 Bricks, 2 Plates, 1 Tile
8 Studs = 6 Bricks, 1 Plate, 1 Tile
10 Studs = 8 Bricks, 1 Tile
12 Studs = 9 Bricks , 2 Plates, 1 Tile-

Note that the top must always be a tile for an even number of studs.

These equivalents allow flush transitions between Stud-up and Stud-side construction.

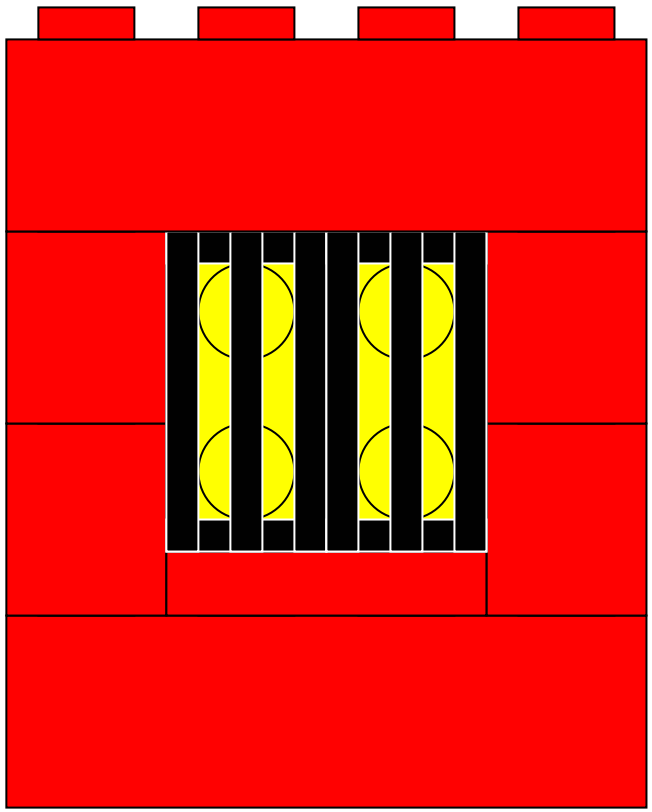
Odd Number of Studs

1 Studs = 2 Plates
3 Studs = 2 Bricks, 1 Plate
5 Studs = 4 Bricks
7 Studs = 5 Bricks, 2 Plates
9 Studs = 7 Bricks, 1 Plate
11 Studs = 9 Bricks

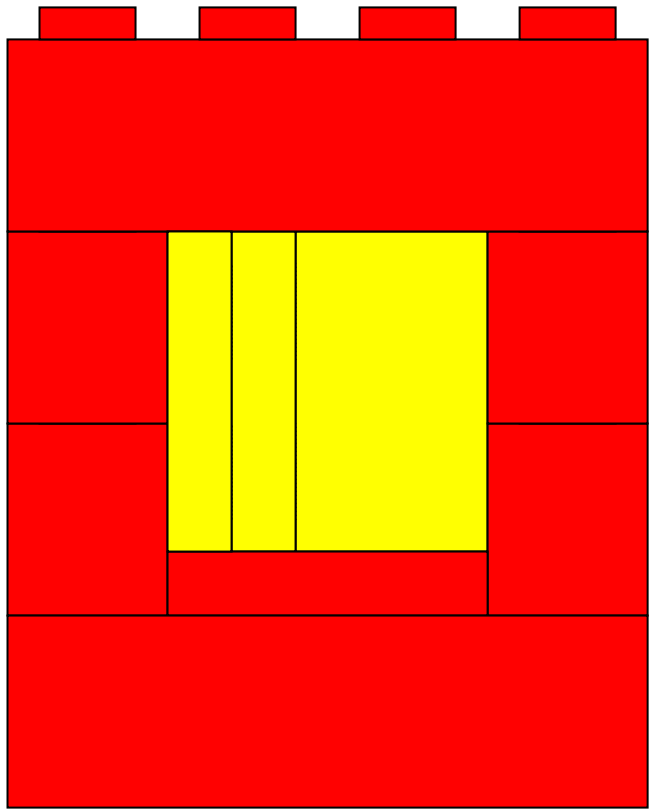
Note that the Studs are required for an even height match for an odd number of studs.

These equivalents are often useful internally to provide a snug non-stud connection.

Stud Width to Brick Height
Potential Uses

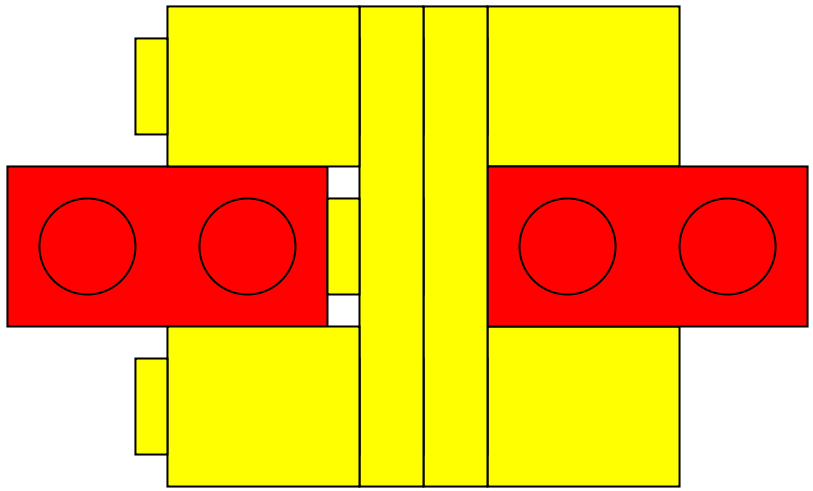


Even Stud Width,
Studs facing out



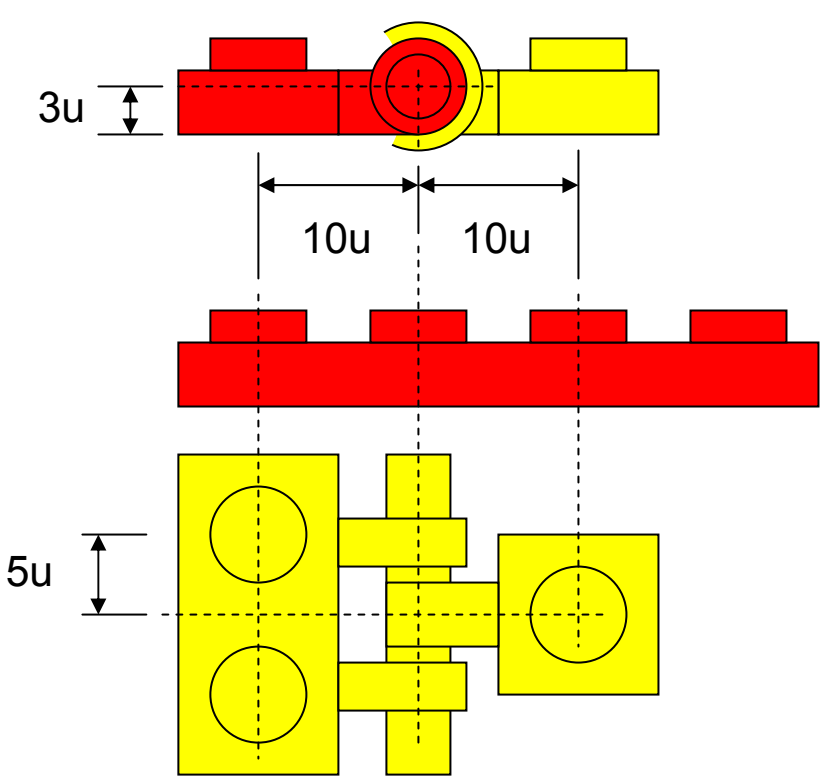
Even Stud Width,
Studs facing to side

Stud Width to Brick Height Potential Uses

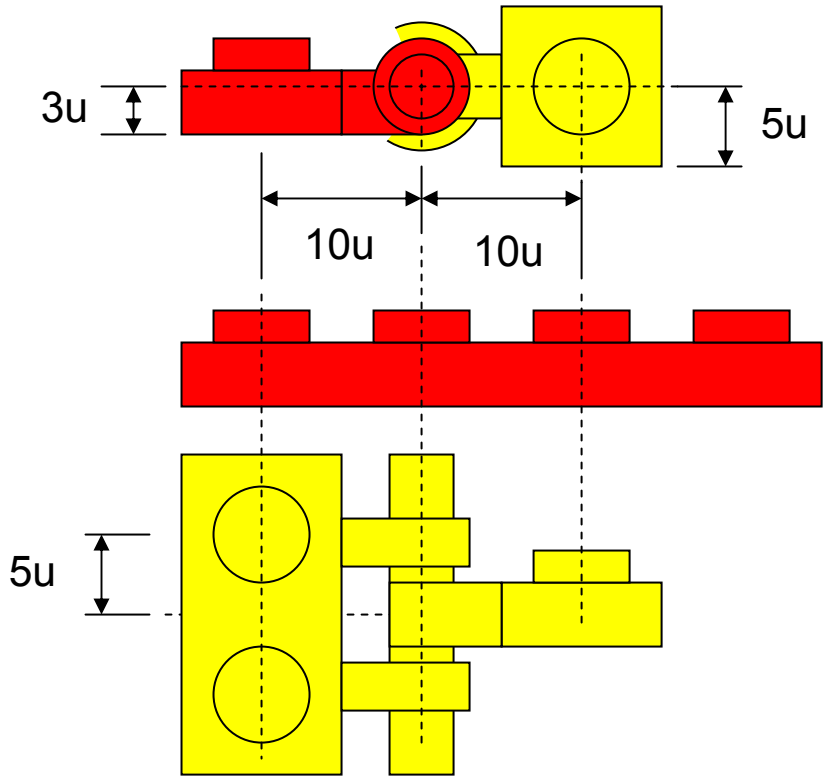


Odd Stud Width – Snug fit, but works well for holding stud-to-side mounted pieces on models

Rod & Clip

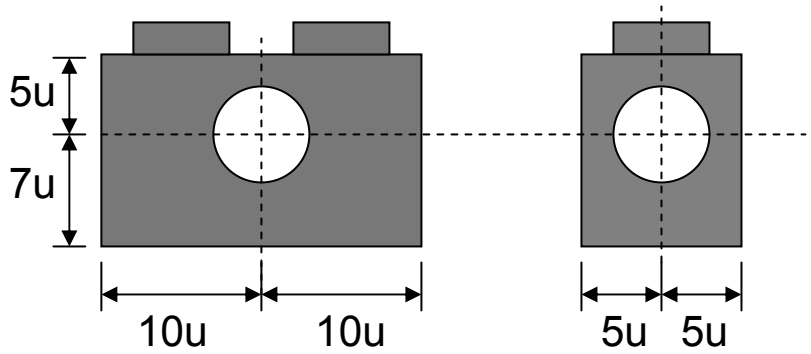


Same Stud orientation,
using Horizontal Clips



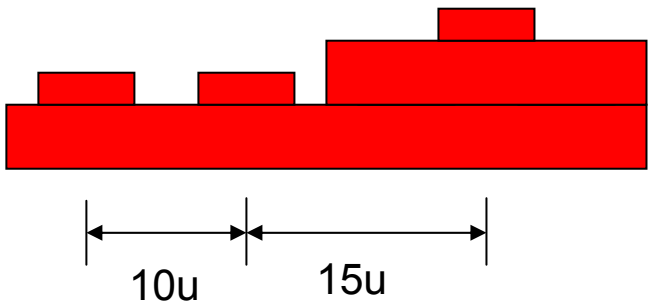
Change Stud orientation,
using Vertical Clips

Technic Brick & Pin



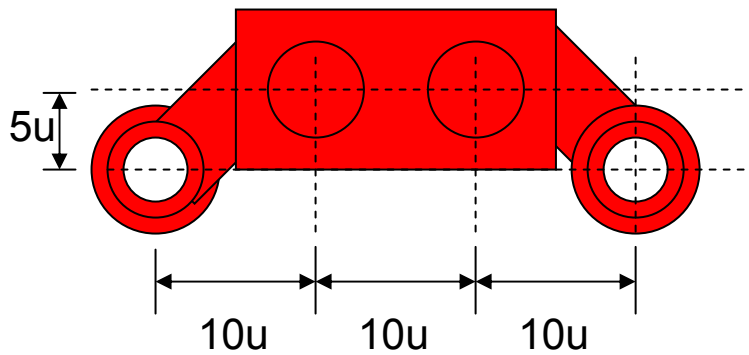
Technic bricks used with stud-pins provide flush mounting either on stud allignment or with ½ stud offset.

Half Stud Offset

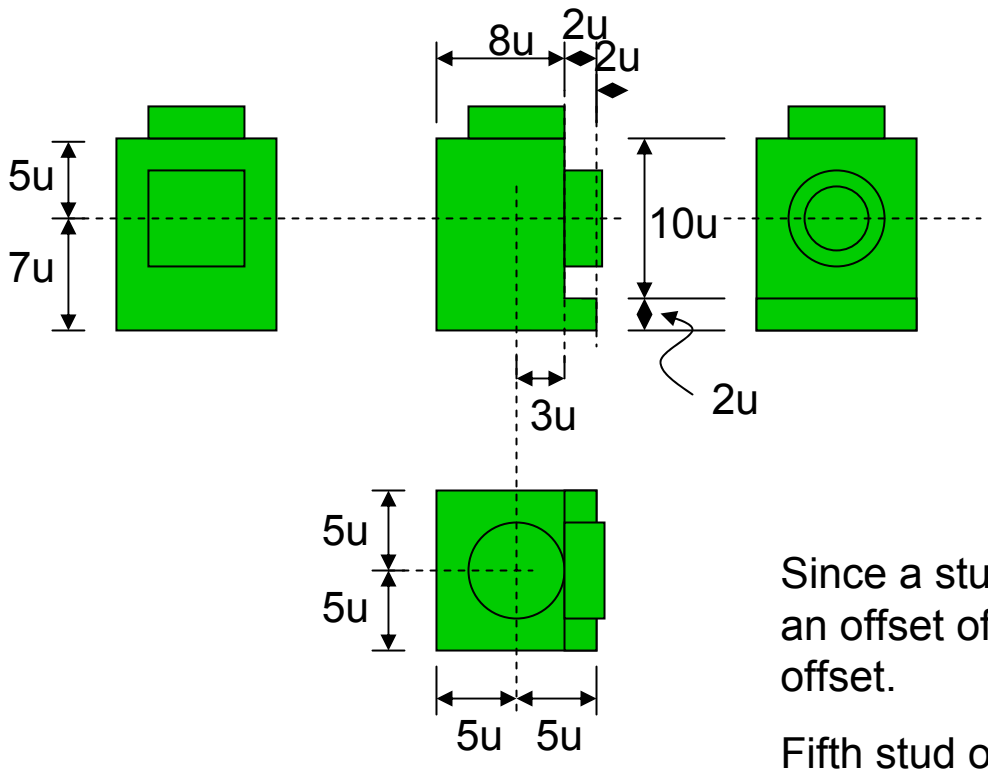


Half stud offset pieces have a Plate height, but when used, they move all geometries to an odd number of units.

Another good half stud offset piece is the 1x4 plate with offsets. It has two studs that are offset by ½ stud in one direction. All studs line up on stud boundaries in the other direction.



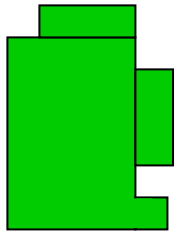
Fifth Stud Offset



Since a stud is 10 units across, an offset of 2 units is a 1/5 stud offset.

Fifth stud offsets can be obtained several ways. For example, using the 1x1 brick with a side stud or using the 1x2-1x4 plate bracket.

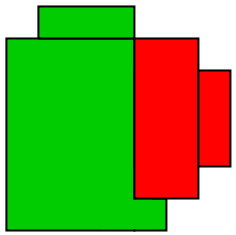
Fifth Stud Offset



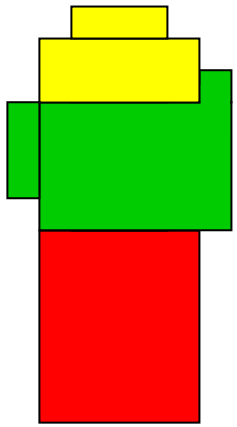
Once face of this brick is set back by 1/5 of a stud.

If you put a plate on the front, the stud is protruding by 1/5 of a stud width.

Flush stud receiver connection on this side



1/5 stud offset stud connection on this side

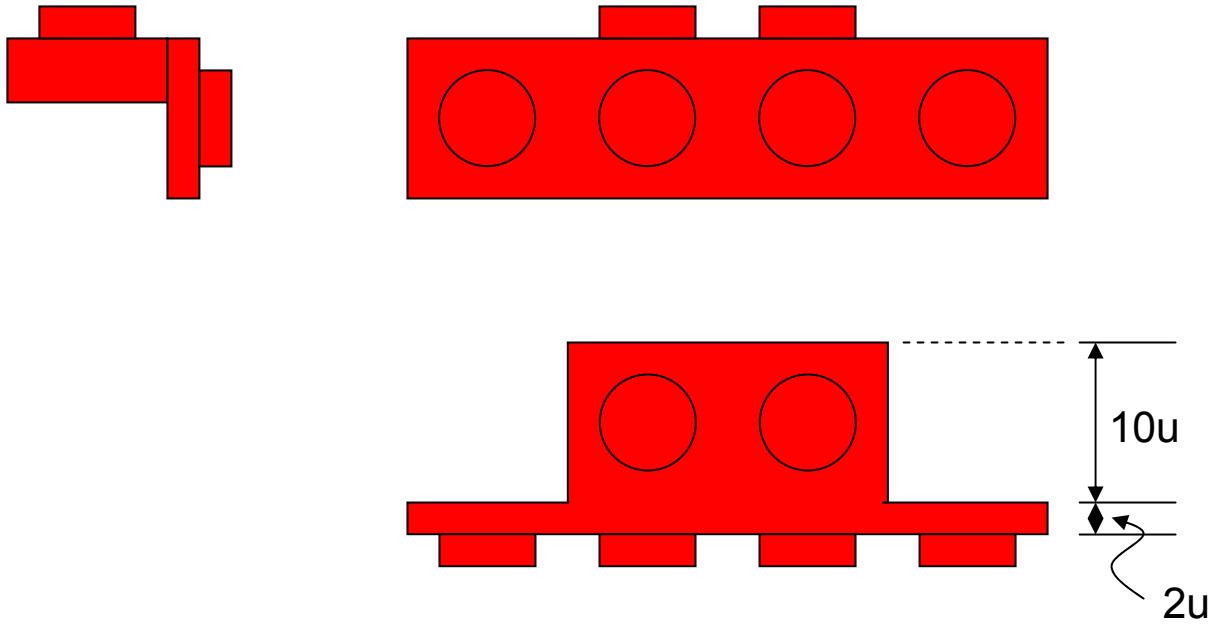


Flush stud connection on this side

1/5 stud offset stud receiver connection on this side

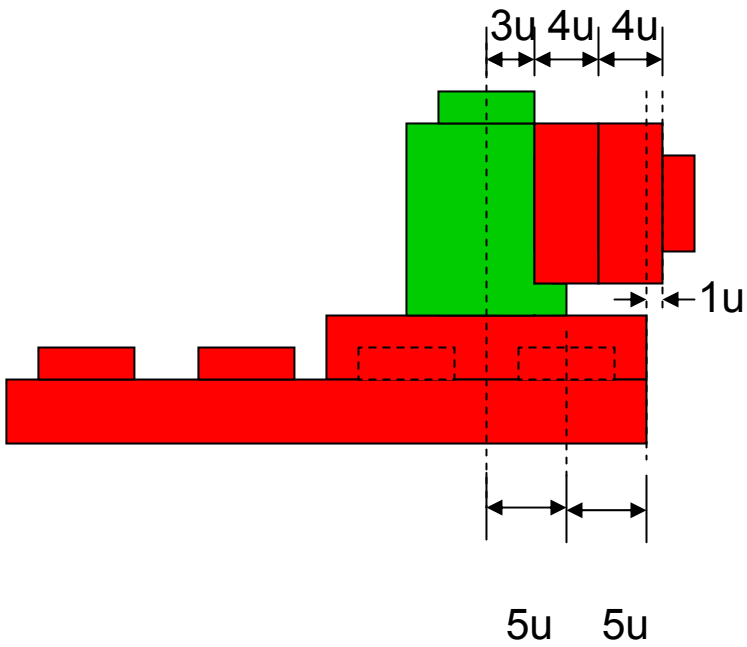
If you rotate the brick 90 degrees and use the square hole on the back to connect to a stud, you can use the bottom of the brick to provide a 1/5 stud offset stud receiver on one side, or a flush stud connection on the other side. Placing a plate on the top of the brick makes it come out to an even brick height.

Fifth Stud Offset



Tenth Stud Offset

One way to accomplish Tenth stud offset is to combine the ½ stud offset techniques with 1/5 stud offset technique.



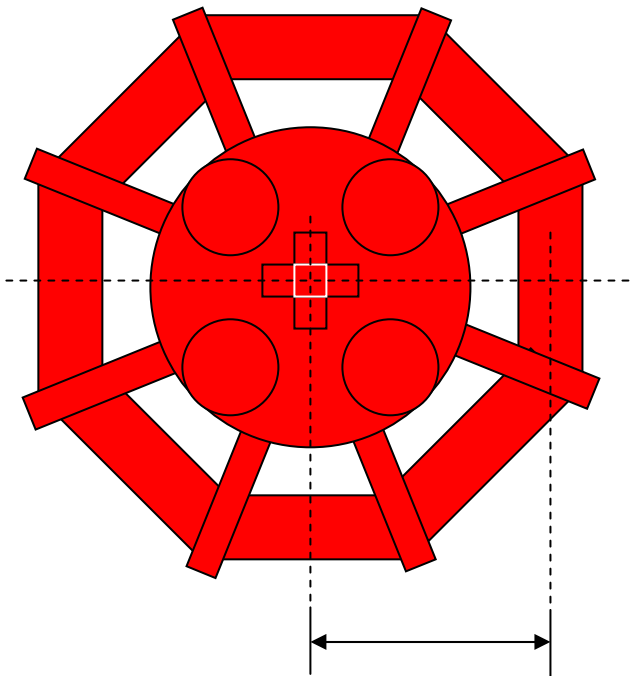
The surface of the second plate is 1/10 of a stud from the edge of the lower plate.

More Fun with Lego and Math

Fun with Rods & Clips

Rod & Clip is one of my favorite techniques because it allows such a wide variety of non-orthogonal angles to be incorporated in a Lego design.

Example: An octagonal tower roof for a cathedral.
Basic design: Eight sloping wedges come to a peak. Use studs-to-side orientation in order to have a more gradual stepping for the tapering of the tower. Use 2x2 plate w/ octagonal rod to support tapering sides.



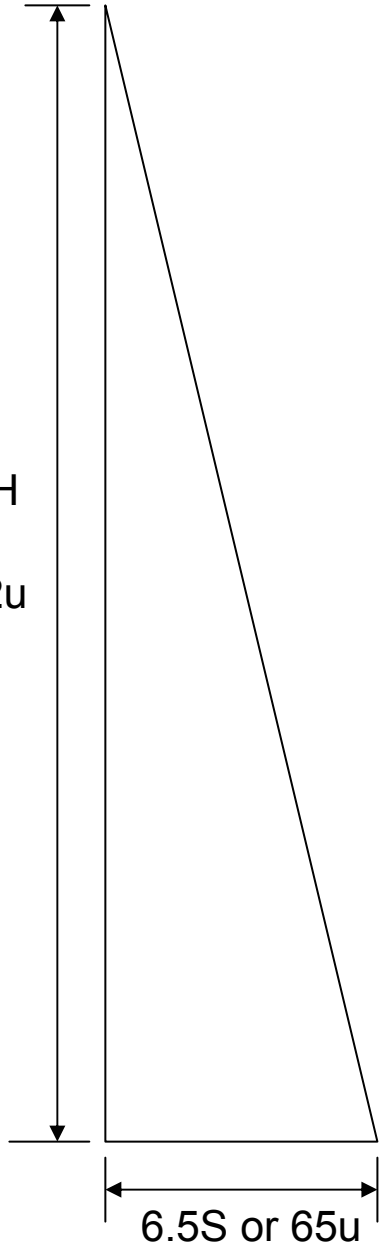
Design calls for a tower roof that is 14 studs across at the base and about 46 bricks high.

Problem: Where do you place the clips, so that the sides of the octagonal roof come together properly at an even rate?

In profile, This piece is the same as the 1x2 plate with the horizontal rod.

I used the 1x1 plate with the vertical clip to change the stud orientation.

Fun with Rods & Clips (cont)



Slope: To determine the slope, look at where the base starts and where the peak ends. I left a ½ stud clearance around the base of the tower, leaving 13 studs for the tower.

We have 528u to go up, for a horizontal travel of 65 units.

552u/65u = 8.4

Since the minimum horizontal change is 1 plate (4u) this means that the rise for 1 plate change would be ~34u or just under 3.5 studs. Since it is difficult to do a 3.5 stud run, I selected to extend that to a 4 stud run. Thus, the slope turnd out to be 4 studs (40u) per plate (4u), or:

rise/run = 40u/4u = 10

Fun with Rods & Clips (cont)

Create formula to determine the position of the center of the clip for various positions along the tower peak. We need X to be 15 units or as close as possible to that, so that the clip matches up with the rod. And Y needs to be an even multiple of 4 units so that we can adjust the height of the octagonal rod plate using bricks and plates, to match up with the clip.

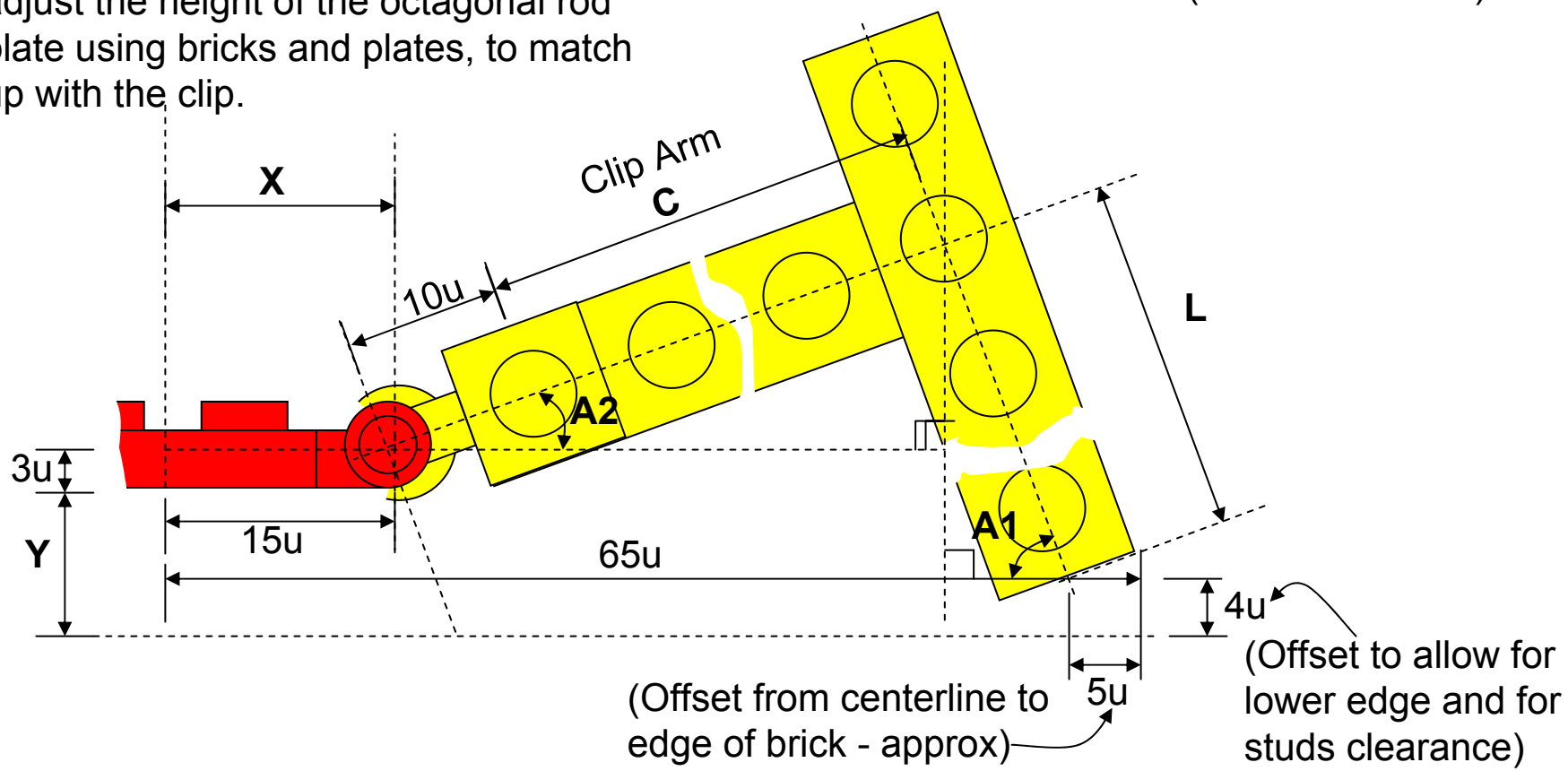
X = 65u – 5 – **L***cos(**A1**) – **C***cos(**A2**)

Y = 4 + **L***sin(**A1**) – **C***sin(**A2**) - 3

L = (number of studs)*10 – 5

A2 = 90 – **A1**

C = (number of studs) * 10



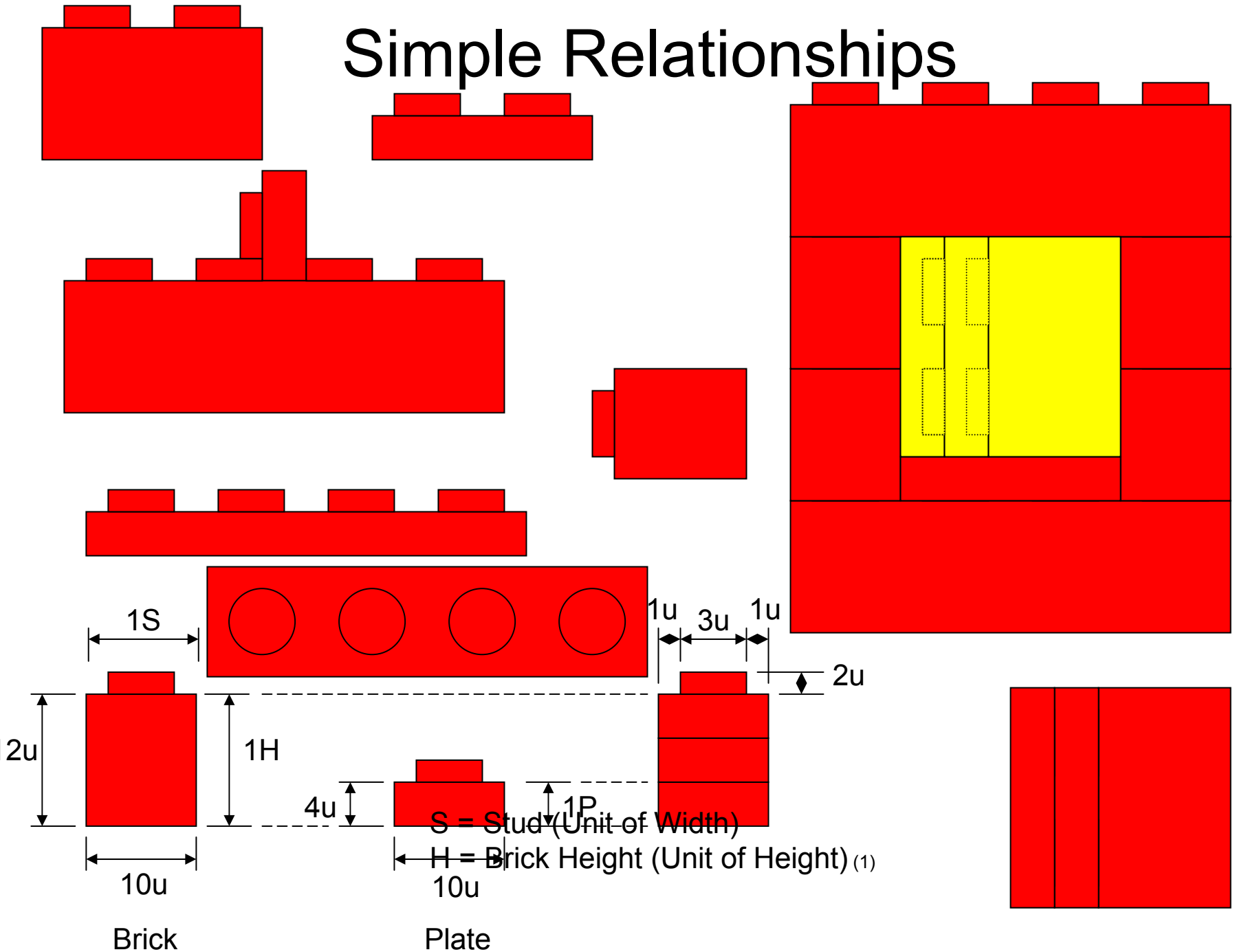
Fun with Rods & Clips (cont)

		C=	2						C=	3						C=	4					
n	L		X	Y	ModX	ModY	Y(h)	+Y(p)		X	Y	ModX	ModY	Y(h)	+Y(p)		X	Y	ModX	ModY	Y(h)	+Y(p)
1	5		24.6	4.99	4.6	0.99	0	1.25		14.7	3.99	4.65	0.01	0	1		4.7	3	4.7	1	0	0.75
2	15		23.6	14.9	3.61	1.06	1	0.73		13.7	13.9	3.66	1.94	1	0.49		3.71	12.9	3.71	0.95	1	0.24
3	25		22.6	24.9	2.61	0.89	2	0.22		12.7	23.9	2.66	0.11	1	2.97		2.71	22.9	2.71	1.1	1	2.72
4	35		21.6	34.8	1.62	1.16	2	2.71		11.7	33.8	1.67	1.84	2	2.46		1.72	32.8	1.72	0.85	2	2.21
5	45		20.6	44.8	0.62	0.79	3	2.2		10.7	43.8	0.67	0.21	3	1.95		0.72	42.8	0.72	1.2	3	1.7
6	55		19.6	54.7	0.37	1.26	4	1.68		9.68	53.7	0.32	1.74	4	1.44		-0.3	52.7	0.27	0.75	4	1.19
7	65		18.6	64.7	1.37	0.69	5	1.17		8.68	63.7	1.32	0.31	5	0.92		-1.3	62.7	1.27	1.3	5	0.67
8	75		17.6	74.6	2.36	1.36	6	0.66		7.69	73.6	2.31	1.64	6	0.41		-2.3	72.6	2.26	0.65	6	0.16
9	85		16.6	84.6	3.36	0.59	7	0.15		6.69	83.6	3.31	0.41	6	2.9		-3.3	82.6	3.26	1.4	6	2.65
10	95		15.6	94.5	4.35	1.46	7	2.63		5.7	93.5	4.3	1.54	7	2.39		-4.3	92.5	4.25	0.55	7	2.14
11	105		14.7	104	4.65	0.49	8	2.12		4.7	103	4.7	0.51	8	1.87		-5.2	102	4.75	1.5	8	1.62
12	115		13.7	114	3.66	1.56	9	1.61		3.71	113	3.71	1.44	9	1.36		-6.2	112	3.76	0.45	9	1.11
13	125		12.7	124	2.66	0.39	10	1.1		2.71	123	2.71	0.61	10	0.85		-7.2	122	2.76	1.6	10	0.6
14	135		11.7	134	1.67	1.66	11	0.58		1.72	133	1.72	1.34	11	0.34		-8.2	132	1.77	0.35	11	0.09
15	145		10.7	144	0.67	0.29	12	0.07		0.72	143	0.72	0.7	11	2.82		-9.2	142	0.77	1.7	11	2.58
16	155		9.68	154	0.32	1.76	12	2.56		-0.3	153	0.27	1.25	12	2.31		-10	152	0.22	0.25	12	2.06
17	165		8.68	164	1.32	0.19	13	2.05		-1.3	163	1.27	0.8	13	1.8		-11	162	1.22	1.8	13	1.55
18	175		7.69	174	2.31	1.86	14	1.54		-2.3	173	2.26	1.15	14	1.29		-12	172	2.21	0.15	14	1.04
19	185		6.69	184	3.31	0.09	15	1.02		-3.3	183	3.26	0.9	15	0.77		-13	182	3.21	1.9	15	0.53
20	195		5.7	194	4.3	1.96	16	0.51		-4.3	193	4.25	1.05	16	0.26		-14	192	4.2	0.05	16	0.01
21	205		4.7	204	4.7	0.01	16	3		-5.2	203	4.75	1	16	2.75		-15	202	4.8	2	16	2.5
22	215		3.71	214	3.71	1.94	17	2.49		-6.2	213	3.76	0.95	17	2.24		-16	212	3.81	0.05	17	1.99
23	225		2.71	224	2.71	0.11	18	1.97		-7.2	223	2.76	1.1	18	1.72		-17	222	2.81	1.9	18	1.48
24	235		1.72	234	1.72	1.84	19	1.46		-8.2	233	1.77	0.85	19	1.21		-18	232	1.82	0.15	19	0.96
25	245		0.72	244	0.72	0.21	20	0.95		-9.2	243	0.77	1.2	20	0.7		-19	242	0.82	1.8	20	0.45
26	255		-0.3	254	0.27	1.74	21	0.44		-10	253	0.22	0.75	21	0.19		-20	252	0.17	0.25	20	2.94
27	265		-1.3	264	1.27	0.31	21	2.92		-11	263	1.22	1.3	21	2.67		-21	262	1.17	1.7	21	2.43
28	275		-2.3	274	2.26	1.65	22	2.41		-12	273	2.21	0.65	22	2.16		-22	272	2.17	0.34	22	1.91

Spread sheet to calculate X & Y Clip positions

Leftover pieces

Simple Relationships



S = Stud (Unit of Width)

H = Brick Height (Unit of Height) (1)