



# I. Preparing your materials

## material list

10 feet of 1/2-inch EMT (Electrical Metallic Tubing) pipe

12 feet of 1/8-inch nylon twine

Metal pipe cutter

Ruler Pencil Scissors Marker Pen

	<u>Inches</u>	<u>Centimeters</u>	
C	12 11/16	32.3	1
D	11 15/16	30.4	2
E	11 1/4	28.6	3
F	10 15/16	27.8	4
G	10 1/4	26	5
A	9 11/16	24.6	6
B <sup>b</sup>	9 3/8	23.8	minor 7
C	8 7/8	22.5	8
optional Major 7th: B natural			
B <sup>n</sup>	9 1/8	23.2	Major 7

**Step 1:** Use your ruler and pencil to measure and mark your EMT pipe to the eight lengths on the right, i.e., C, D, E, F, G, A, B<sup>b</sup>, C.



Note: Our music will not use B<sup>n</sup> (B natural). However, we have also listed it here for those of you who want your instrument to play the Major 7th in the scale.

**Step 2:** With a metal pipe cutter (not a hacksaw), cut the tubing at each of your marks. Start by cutting the longest pipe, and then proceed with the shorter lengths. If you accidentally cut a pipe too short, simply set the pipe aside and re-cut it for one of the shorter notes above. If you accidentally cut a pipe too long, you may sand or grind the pipe to shorten its length—or again, just re-cut it for a higher note.



**Step 3:** Hold each tube between your thumb and index finger and strike with a metal spoon. Notice that if you hold the tubes too close to the ends (or the middle) they don't vibrate with a nice long sound. Instead you just hear a short "tink." Find the place to hold your tubes so they sound their best—this is where you will eventually tie your strings.



**Step 4:** With your scissors, cut your nylon twine into two 6-foot sections.





## II. Building your Glockenspiel

**Step 5:** Using your marker pen, label each tube with a number from the table on page 2. Write the number in the middle—remember, tube number 1 is the longest and tube number 8 is the shortest.



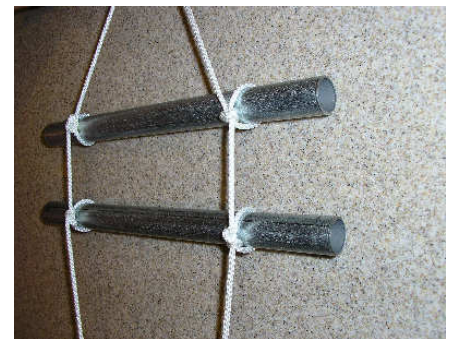
**Step 6:** Tie a simple knot around tube 8, the shortest tube. Leave 8-10 inches (20-25cm) of twine above the tube.



**Step 7:** Make another simple knot and position the twine about 2 inches (5cm) from the end. With a ruler, recheck that you have 8-10 inches (20-25cm) of twine above the tube.

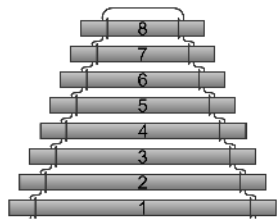


**Step 8:** Using your other piece of twine, repeat steps 5 and 6 on the other end of the tube. Now continue and repeat with tube 7. Space your tubes about 2 inches (5 cm) apart.



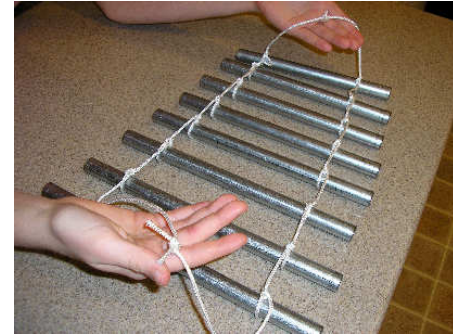
**Step 9:** Repeat steps 5 through 7 with your other tubes — 6, 5, 4, 3, 2 and 1. Arrange your knots and twine so they run down one side of the tubes. The string and knot side will be the back—the other side will be the front.





### III. Playing your Glockenspiel

**Step 9:** Tie knots on the top and bottom ends of your twine.



**Step 10:** Arrange your tubes so that the numbers are all facing the same direction—the front of the glockenspiel.



**Step 11:** Check that your knots are positioned to allow each tube to vibrate with a nice long sound (refer to step 3).



**Step 12:** Using a metal spoon, gently strike each tube in the middle. Notice that you may hold or hang your glockenspiel. If you prefer, you may also lay your glockenspiel on a table—knot side down.





# IX. 2014 Science Olympiad Addendum



## sounds of music event

If you're building an instrument for the 2014 Division B Science Olympiad Competition, the pipe lengths on the right will apply to "Instrument 1." We have included all 27 pitches in the "allowable scoring range" between F3 and G5. Additionally, we have highlighted the exact pitches that are required for the "F Major Scale (F4 to F5)."

The pipes are tuned and calibrated to an A-440 at 72 degrees Fahrenheit. The frequencies they produce are precisely based on the "12 tone tempered scale." You will notice that each octave is divided into twelve equal semitones. Since the frequency ratio of the octave is 2, the frequency ratio  $s$  of this semitone is given by the equation:  $s^{12} = 2$ ;  $s = \sqrt[12]{2} = 1.05946$ .

Please note that all of the pipe lengths are based on **3/4-inch EMT** (not the 1/2-inch pipe listed on page 2). Also, to obtain the best possible sound—that is, a tone in which the fundamental frequency is dominant, and the overtones are almost inaudible—we recommend that you use a soft mallet to strike the pipes.



A yarn or felt-covered mallet works nicely, as well as a rubber ball, screwed into a wooden dowel (above).

Intonation can vary depending on the thickness and brand of the EMT. All of the measurements in this package are based on EMT purchased at Home Depot under the "Allied" brand—the only brand they offered. Lastly, for the absolute best results, we recommend that you use an inexpensive tuner to fine-tune each of your pipes as they are cut. The "Korg CA-30 Chromatic Tuner" is an excellent choice and sells for approximately \$15.

(3/4-inch EMT)

Pitch Name	Tube Length in Centimeters	Frequency in Hertz
F3	48.0	174.610
F#3	45.3	185.000
G3	42.7	196.000
G#3	40.2	207.650
A3	37.9	220.000
Bb3	35.8	233.080
B3	33.7	246.940
C4	31.8	261.600
C#4	29.9	277.180
D4	28.1	293.670
Eb4	26.5	311.030
E4	25.0	329.630
<b>F4</b>	<b>23.5</b>	<b>349.230</b>
F#4	22.0	369.990
<b>G4</b>	<b>20.8</b>	<b>392.000</b>
G#4	19.5	415.300
<b>A4</b>	<b>18.4</b>	<b>440.000</b>
Bb4	17.3	466.160
B4	16.3	493.880
<b>C5</b>	<b>15.4</b>	<b>523.250</b>
C#5	14.4	554.370
<b>D5</b>	<b>13.6</b>	<b>587.330</b>
Eb5	12.7	622.250
<b>E5</b>	<b>12.0</b>	<b>659.260</b>
<b>F5</b>	<b>11.2</b>	<b>698.460</b>
F#5	10.4	739.990
G5	9.8	783.990