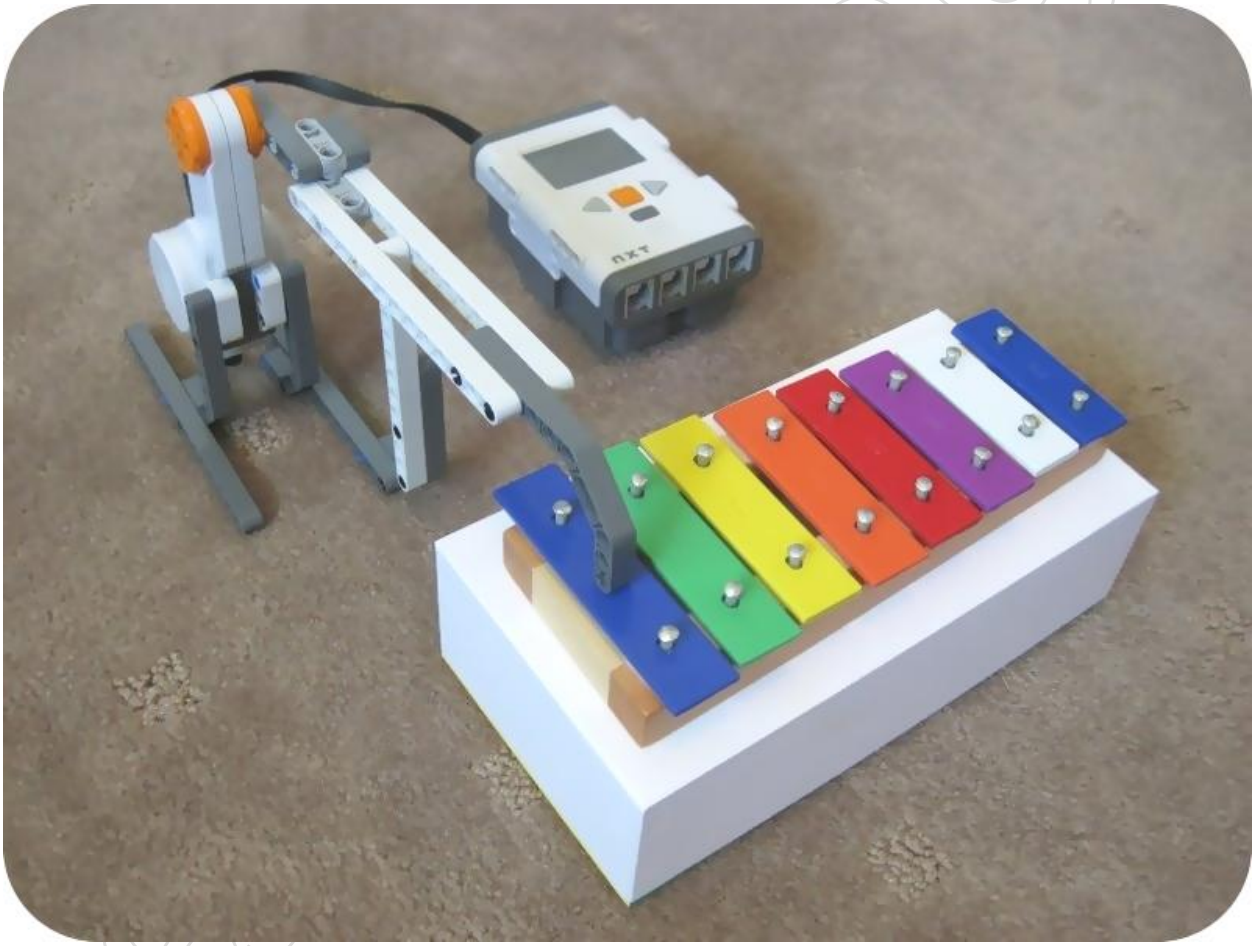
Making Music with the NXT



Making Music with the NXT

Introduction

This book has been created to bring to life the musical capabilities of the LEGO MINDSTORMS system. The focus of this book is not toward 'robotics' but rather the use of the technology to create music. This book is intended for people who have a basic understanding of the LEGO MINDSTORMS system, and are comfortable within the NXT-G development environment moving blocks around and changing parameters in a configuration panel.

If you have had no prior experience with the NXT, then it is highly recommended that you work through the tutorials built into the software or one of the many excellent Teacher Resource books available such as *Classroom Activities for the Busy Teacher: NXT*.

This book will take you through several very different methods of creating music with just a standard NXT kit and some cheap kid's toys that can be purchased from most toy shops.

Whilst it is aimed at teachers using it in a classroom setting, there is no reason why it could not be adapted for use outside the education setting.

You can find videos of the various instruments at the following website, and if you create your own instrument, please let us know about it!

http://www.damienkee.com

All projects in this book make use of any of the LEGO MINDSTORMS NXT systems.

All projects can be built using:

- NXT 1.0 kit
- NXT 2.0 kit
- NXT Education kit

The only exception to this is the Trumpet, which requires three Touch Sensors. Both the Education Kit and the NXT 2.0 kit come with 2 Touch Sensors whereas the 1.0 kit has just one Touch Sensor. This is usually not a problem in a classroom setting where there are typically several kits available, but if you need more, you can purchase them online at the LEGO webstore.

All the non-LEGO instruments were obtained from a regular toy shop. You may need to make some subtle adjustments to make each project work for your particular instruments.

Types of Instruments

Wind: Wind instruments create their sound by blowing into them. The air vibrates through the instrument with various valves, buttons and slides used to change the frequency of the vibration. Common wind instruments include:

- Flute
- Clarinet
- Saxophone
- Trumpet
- Trombone

String: Stringed instruments create their sound by vibrating a string stretched between two points. This can be done with a bow or plucked. Placing the fingers on the string changes the frequency of the vibration and thus the pitch of the note. Most string instruments have several strings, each at a different tension, to give a greater range. Common string instruments include:

- Violin
- Cello
- Double Bass
- Guitar
- Harp

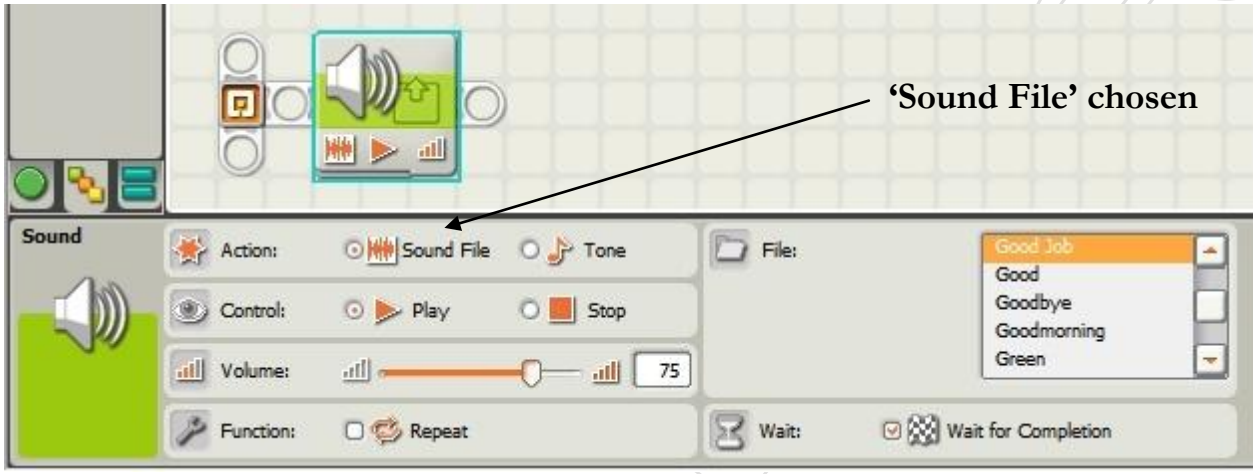
Percussion: Percussion instruments create their sound by hitting or striking parts of the instrument. Some instruments have multiple parts to strike, each tuned to a certain frequency, whilst others create different types of timbre depending on which part you hit. Common percussion instruments include:

- Bass drum
- Cymbals
- Xylophone
- Timpani
- Castanets

Question – What category does a piano fit into?

The Sound Block

The Sound block is the most important block we'll be using in this book, and the associated configuration panel has many different settings we can work adjust.



Sound Block Configuration panel with 'Sound File' Action set.

Action: Here we can choose either a pre-loaded sound file or to play an individual tone (note). If we choose the Sound File section, these are the following options available to us.

Control: Just leave this setting on 'Play'.

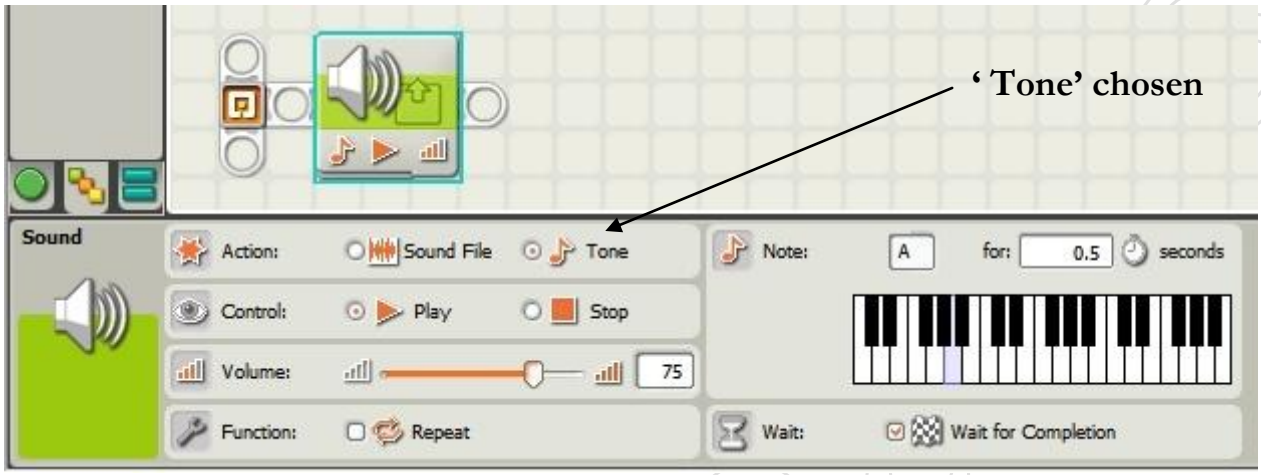
Volume: Controls the volume.

Function: This asks if we wish to repeat the sound over and over again, in most instances we will leave this unchecked.

File: This is the sound file to use. There are many sound files built into the device already such as 'Good Morning', 'Hooray!' and various buzzes, beeps and clicks.

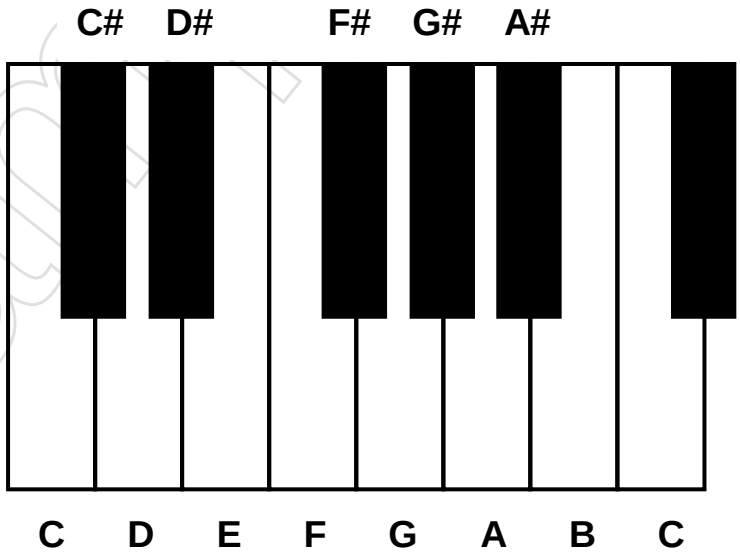
Wait: If the 'Wait for completion' option is checked, then the program will not move on to the next block until the sound has completely finished.

For the vast majority of projects in this book however, will choose the 'Tone' section. This gives us the ability to make music, as opposed to saying words.



Sound Block Configuration panel with 'Tone' Action set.

Control, Volume, Function and Wait are all the same as 'Sound File' configuration panel. What makes the 'Tone' section special is the piano keyboard which is now displayed. We can choose any note we want from that keyboard. The notes start at 'C' on the left hand side and work their way up the musical scale. The notes of a musical scale go from A to G, and then repeat back from A again. If we look at the keyboard in the picture, we can see that each note has a particular name.



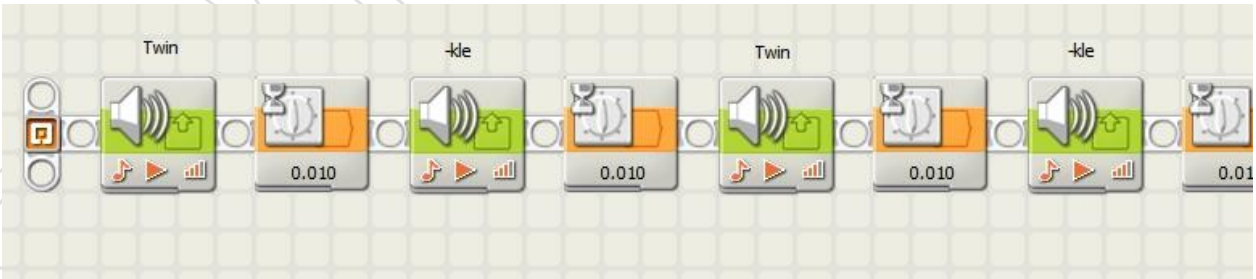
Set each note to play for approximate 0.5 seconds. Program the NXT brick and play your song.

The start of Twinkle Twinkle Little Star. Use the comment function to put small labels above each note.

How does it sound? Probably not how you expected it! There are a few things going on here that just aren't quite musically correct.

- The first few notes run into each other, and there is no break between them
- The last note of each line is not long enough.

To fix the first issue, we need to put a small space between each note. This can be done with an extremely short 'Wait for Time' block between each. For this example, a wait of 0.01 seconds is enough to separate the tone, but not impact significantly on the timing of the music.



A short 0.01 second 'Wait for time' is used to separate the tones.

Ultrasonic Sensor

Using the Rotation Sensor to play music was not particularly easy, as it was tricky to quickly and accurately turn the motor to a particular note. The Ultrasonic Sensor, which measures the distance to an object in either centimetres or inches, provides a better way of varying the input to the NXT brick, and can be more controllable than the Rotation Sensor.

For this musical instrument, we are going to set up the Ultrasonic Sensor to do the following actions:

- Object close = low reading = low note
- Object far = high reading = high note.
- and everything in between

By quickly moving the object backward and forward to several pre-defined distances, we will be able to create a tune!

Object close = low reading = low note

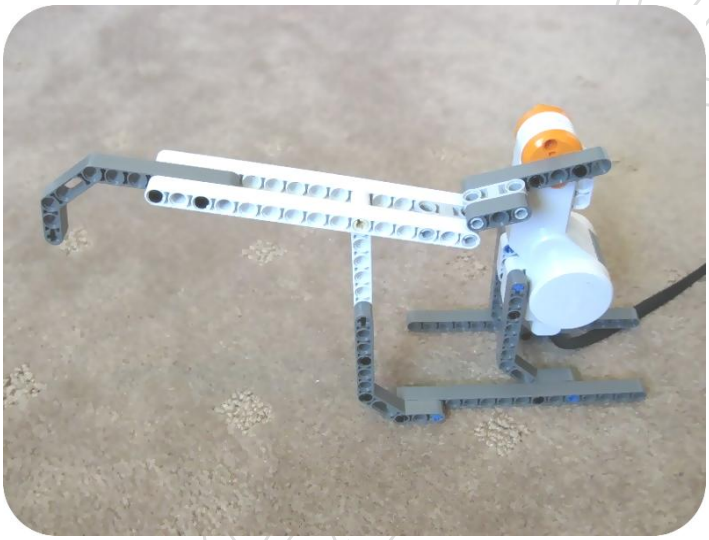
Object far = high reading = high note

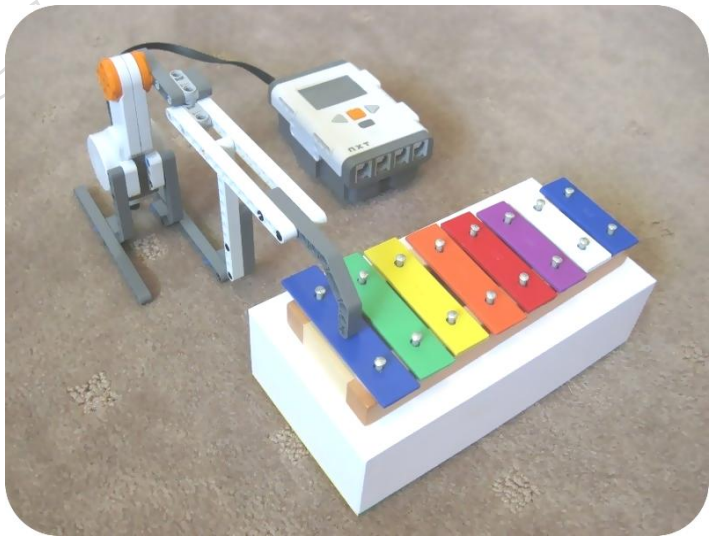
Percussion

Percussion instruments are slightly different in that the notes are generally already set by the instrument, and the musician needs to 'strike' the right one at the right time to play the correct note. So rather than using the internal NXT speaker to create the noise, we will use the NXT to tell a motor when to strike the note.

We are going to start out with a small toy xylophone that you can get from most toy stores. To strike the keys, we will build a device capable of receiving commands from the NXT brick, and bringing down the mallet at the correct times.

Building Instructions for this particular version can be found at the back of the book.





The height and size of your xylophone may be different to the one in the picture, so you may have to do some modifications to make it work best for you.

A full rotation of a motor will result in one xylophone key being struck.

Who's got the Beat?

It's all well and good to have the melody going, but what about a solid beat to hold it all together? Drums do not usually have different notes, but are instead designed to keep a steady rhythm.

Modify the xylophone device to hold a drum stick.

Modified xylophone device to hold a drum stick. Use rubber bands to attach it to the LEGO beam.

Bang the drum

Our first step is to setup a program that can hit the drum just once. Program the drum motor to rotate forward 20 degrees quickly, and then backwards 20 degrees quickly. If you use rubber bands to hold the drum stick to the motor arm, it will give it a little elasticity to bend as necessary. Test with different angles and speeds to get a drum beat that you are happy with.

Hit the drum once.

You may need to adjust the starting position of the drum stick to stop any unwanted bouncing of the drum stick.

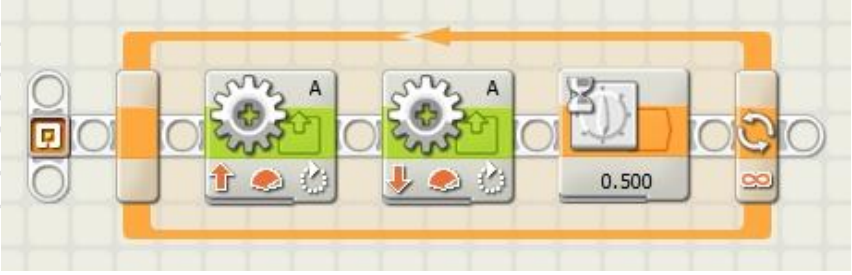
Whole Beats

Our first rhythm comprises just slow whole notes. By placing a 'Wait for Time' block after the beat has been struck, and placing the whole program in a loop, will create a slow steady rhythm.

Slow, constant 1 second beat.

Half Beats

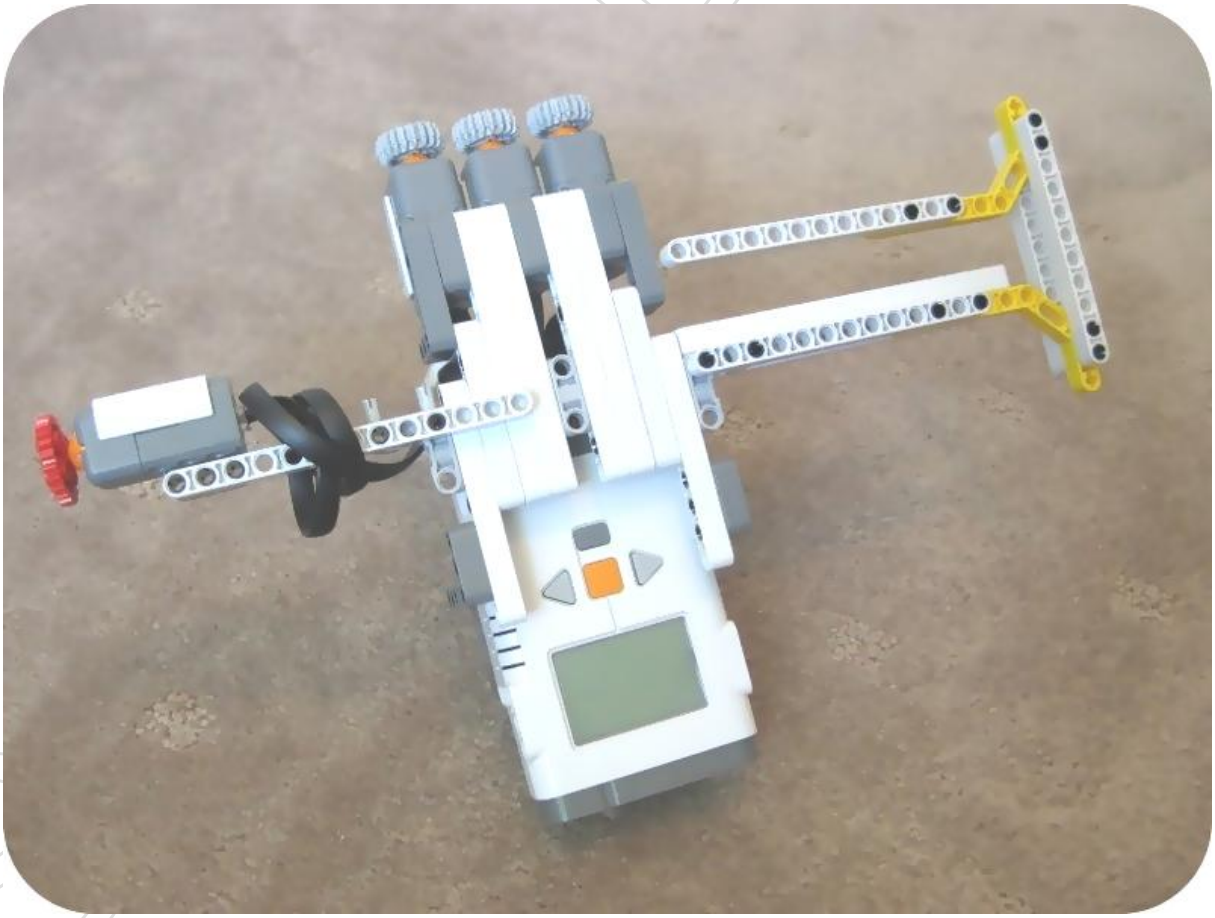
These are the same as whole note, only the 'Wait for time' block is halved to 0.5 seconds. Program it in and hear the difference.



Faster half beats.

Trumpet

Now for something a little different! The trumpet styled robot from this chapter uses three Touch Sensors, similar to the three valves on a real life trumpet. By reading the different combinations of inputs from these Touch Sensors, it will be possible to generate different notes.



LEGO Trumpet

The three Touch Sensors each can be in one of 2 positions, pressed or released. This gives us a total of 8 different combinations. If we assign each combination of Touch Sensors to a note we can get one octave of a C major scale.

First Touch Sensor	Second Touch Sensor	Third Touch Sensor	Note Played
Released	Released	Released	C
Pressed	Released	Released	D
Released	Pressed	Released	E
Pressed	Pressed	Released	F
Released	Released	Pressed	G
Pressed	Released	Pressed	A
Released	Pressed	Pressed	B
Pressed	Pressed	Pressed	C

For those of you who play trumpet you will recognise that this is not the same combination to generate notes on a real trumpet. Proper trumpet players can make fancy shapes with their mouth called 'embouchure' to create different notes as well.

Research Assignment

Find an instrument from another country or another age in history.

What is the history of the instrument?

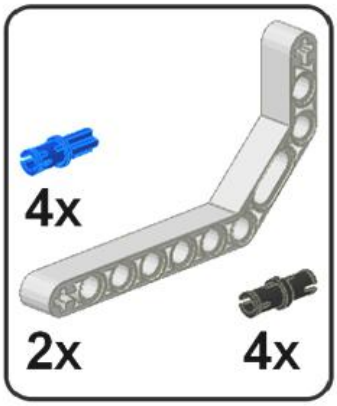
What category does it fall into? Wind String Percussion Other?

What material is it made from?

Draw or attach a picture of the instrument below.

Xylophone Striker Build Instructions

1



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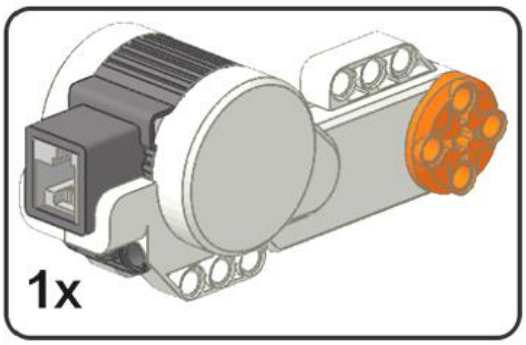

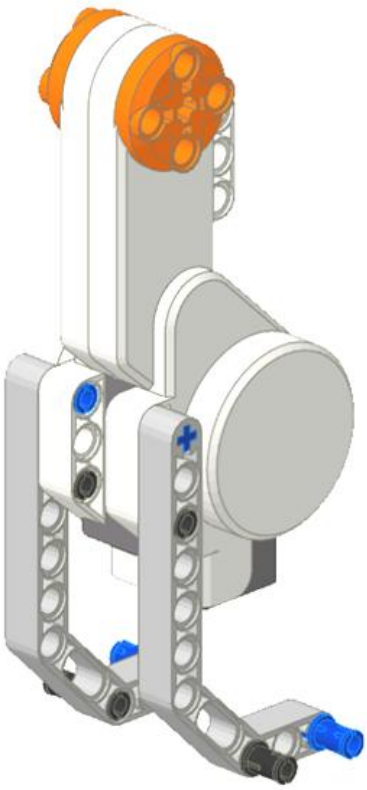

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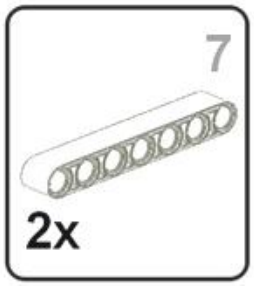

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