

# STRUCTURE CONCEPTS

## ► BODY BUILDING

***Note To Teachers:** If you would like Professor Bible and a group of UC Architecture students to come to your class to do a Body Building session, please contact Tom Bible at 513-556-0411 to schedule a visit. There is no fee for this activity. There are more activities in this series developed by Professor Bible than are listed here.*

### Introduction

The human body is a structure. It carries loads all day. The biggest load it carries is itself, but it also is able to carry other imposed loads that placed on it - books, backpacks, helmets, and sometimes friends. Body Building is about using your body to feel how structures work.

### Body Building - Part 1 Feeling the Forces

#### Compression

Have all the students stand up. Have them place their hands on their heads with your fingers interlaced. Ask them to push down. Ask, "How does your neck feel? Squished together?" Tell them, "This is compression; the force that an arch or a column or a tower of a suspension bridge experiences." Then ask, "Can you feel the same squished forces in your back or in your legs? When do your legs feel this way, when you lift heavy objects? Have the students offer their own answers. Share when you feel compression.

#### Tension

Still standing, with hands still on heads, pushing down, ask students, "Does any part of you feel stretched out?" Their arms, fingers or wrists might feel a stretching force. Tell the class, "Stretching is a tension force." Now ask them to stretch straight upwards by reaching for the ceiling. Ask them, "Do you feel stretching forces in your arms, back and legs?"

Have students pair up, stand to face each other at arms length, hold both hands and pull back gently. Their arms will be in tension. Ask if they can feel it. Now ask them to slowly increase the pull. Ask if they feel more of their body working. More force makes the body work harder.

Have the class all stand up. Ask them to bend over and touch their toes. Ask, "What part of you is stretched?" They should feel the tension, a stretch, all around the back part of the body (heels, calves, back and even shoulders.)

#### Now we can talk about Bending

While the class is still bent over, they have tension around the backside of the body. Ask them if they also feel compression (squeezing together) all around the front. "Is your belly squeezed up a bit?" This is bending. Structures in bending have tension across one surface and compression across the other. This is demonstrated in the third paper bridge in the Beam Bridge section of Paper Architecture.

Have students stand up straight, and to push with one hand on the side of their head. Tell them to not resist with their neck muscles, but let the head tilt with the push. Ask them, "Can you feel which part of your neck is compressed?" It should be the side away from the pushing hand. "Which side is in tension?" It should be the side the push is coming from.

Now ask them to use their neck muscles to keep the head straight while pushing. Ask them, "Do the forces reverse?" If your neck pushes hard enough, you will feel compression on the side next to your hand and tension on the other side away from your hand.

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### **Bones and Muscles**

Our structural bodies use bones and muscles to carry loads. Generally, we use our bones to carry compression. They have a lot of strength when they are loaded in their long directions. But it is harder to use bones in tension. Usually, when we stretch, our muscles and tendons are stretched to carry the tension force.

Have students divide into pairs. One stands with arms straight out from her sides. The other places a book on each outstretched hand. Have them then slowly flex their arms at the elbows to raise the books. The upper arm should go straight out from the shoulder and stay level with the floor. Ask them, "What is happening here?" The muscle in the top of your arm, your bicep, is producing a tension force (muscles work by shortening) and your upper arm bone, your humerus, is in compression. When you lower the books slowly your top muscle, the bicep relaxes, while your bottom muscle, the tricep, is stretching to pull the arm back down.

### **Body Building Part 2 Experiencing Two Bridge Types**

#### **Arch Bridge #1**

Have students divide into pairs. Have one student place their elbows on a table and grasp their hands together. Next, have the other student push straight down on their hands. Ask them if their arms feel a compression force (being pushed down). The student's arms have made an arch. Ask if they can hold more straight down force with hands locked together or with just one hand alone? How much more? twice the load? Have the 'load' student push against their arms side to side (parallel to your shoulders). Ask them if one arm feels compression and one arm feels tension or stretching. Which arm is in Compression? Which one is in tension? Usually the arm that the pushing is going toward will be in compression, the arm that the pushing is coming from will be in tension. Can you carry more sideways (lateral) force with two arms or one? How much more, twice or more? With two arms locked you would be more stable - that means you can carry forces in more directions. The two-arm structure, however, is not very stable if the load student stands in front and pulls the hands away.

#### **Arch Bridge #2**

Have two students stand face to face about 5 feet apart (for students who are at least 4' tall... smaller students will need to be closer). Now help them lean forward so that their hands will grab each other's shoulders. Tell the students to step back a little at a time, bending at the waist until their arms and legs are straight. When they feel their hands pushing against each other, have made an arch that is holding part of their weight. Ask if they feel the compression in their shoulders, do they feel their feet are about to slide? Have two other students brace the two 'arched' students' heels with their feet. These two are now the buttresses.

#### **Suspension Bridge**

Some of the earlier exercises that we did using compression and tension simulate parts of the suspension bridge. When you are pushing down on your head with two hands, you feel like the tower of a suspension bridge might feel. When you and a friend are pulling each other's arms, you feel the forces that are in a cable.

This exercise requires four people and a heavy object, like a desk chair. Place the chair in the middle of your space. Be sure that there is plenty of room (10 feet) around it. Have two people stand beside the chair - one on the right and one on the left. They should face the same direction. The person on the right of the chair grabs the top with the left hand and the person on the left grabs the top with the right hand. The two people are the bridge towers and their arms holding the chair are the bridge cables. Lift the chair. Do the two towers tend to lean in toward each other? What happens if each person has his legs spread apart? More stable? What happens if their legs are close together?

Now have two people kneel or sit, one next to each tower. They should be two or three feet away from the towers so that everybody, including the chair, make one straight line. Have the kneelers reach up and take the free hand of the towers. The kneelers are the counterweights or backstays for the towers. How do the towers feel? Does each arm have the same amount of stretch in it? If you were to add load to the chair, a couple of big books maybe, do the backstays have to compensate by pulling more?