聲音看得見 Visualized Sounds

校名：莊敬國小
指導老師：王雪蓉、陳姵均
胡光達、林文憲

聲音只能聽得到，摸不到也看不到，如何看見聲音呢？以下介紹三種有趣的操作。We can only hear sounds. We can't touch them , nor see them. Here are 3 interesting ways to see them.

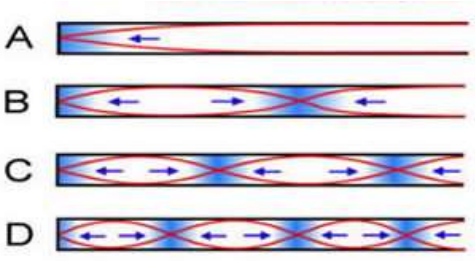
想探索聲音氣流的神奇力量嗎？只要利用簡單的器材，運用聲音氣流原理，就能順利通過各項關卡，請用心思考、大膽嘗試，這項利用「聲音氣流」的闖關特別任務就等你來完成囉！
Wanna explore the magical power of air flow of sounds? With simple materials and the principles of sound, and you can pass the challenges. Plz think carefully and try fearlessly. You can do it.

原理 Principle

聲音是一種波動，聲音的振動會引起介質——空氣分子有節奏的振動，使周圍的空氣產生疏密變化，形成疏密相間的縱波，這就產生了聲波，這種現象會一直延續到振動消失為止。
Sound is a kind of wave. Sound vibrations cause air to vibrate rhythmically making rarefaction waves which are called sound waves. This phenomenon will last until it stops.

聲音是空氣的一種疏密波（縱波），在管子中振動時，會產生駐波（standing wave），並使得保麗龍球形成固定的波形，在波腹與波節之間振動。如下圖，音波管的管子一端為封閉，圖中管子長度是聲音波長的 n/4 倍（A～D 的 n 分別為 1、3、5、7…）。由於我們發出的聲音的波長，未必固定不變；加上嘴巴吹出氣流的擾動，使得保麗龍球的波形會有前後移動的現象。
Sounds are rarefaction waves of air. When they vibrate in the tube, it causes standing waves making styrofoam balls take shape of certain waves. As in the following picture, one side of the sonic tube is closed. The constant change of wavelengths and disturbance of airwaves our mouths caused, make the waveform of styrofoam balls move.

手指頭在杯口摩擦時，能夠讓杯子產生震動（這種震動能夠由杯子裡的水產生波動觀察出來），進而讓空氣振動而產生聲音。而杯子的質量越大，震動會越慢，因此杯子越大或是加了水，聲音都會變低。



Fingers rubbing on top of glass makes it vibrate, which can be seen by the wave of water in the glass, causing the air to vibrate and make sounds. The larger the mass of the glass is, the slower the vibration will be. Therefore, the larger the glass or more water it contains, the lower the sound will be.

一、 目的 Purpose

請闖關者運用聲音的波動造成氣流的壓力差，進而震動如圖一的裝置，利用雷射筆放出的光被反射在牆壁上，然後在紙筒後面發出聲音，就可以看到雷射筆反射的光點開始振動，光點的振動圖形隨著聲音的變化而變化（如圖二），相當多樣性而有趣！

Students make sounds to vibrate the device as in Picture 1 with the pressure

difference caused by sound vibrations. Then use the laser pen to reflect the light spot on the wall. We can see the reflection of light from the laser pen start to vibrate and its patterns change with the sounds. It's interesting and fun.

二、實驗器材

1. 紙筒、塑膠袋、雷射筆、橡皮筋、膠帶、保麗龍、紙板
   paper cylinders, plastic bags, laser pens, rubber bands, tape, Styrofoam, paperboards
2. 塑膠管、保麗龍球、西卡紙、大吸管(紙杯、毛根)
   plastic tubes, Styrofoam balls, cardboards, thick straws (papercups, pipe cleaners)
3. 高腳杯（玻璃杯）數個
   wine glasses / water goblets

三、活動過程

1. 第一關，如圖一的裝置，利用雷射筆放出的光被反射在牆壁上，然後在紙筒後面發出聲音，就可以看到雷射筆反射的光點開始振動，光點的振動圖形隨著聲音的變化而變化（如圖二）只利用不同方式製造出聲音使其產生氣流，分別讓鏡子產生波動即可過關。

   Level 1 - Use a device as shown in Picture-1 to reflect the light of the laser pen on the wall. Then make sounds from the other side of a paper cylinder. We can see the light spot of the laser pen starts to vibrate and the shapes change with the sounds as in Picture-2. Use different ways to make soundwaves and make the shape vibrate; then you pass Level-1.
2. 第二關，雙手握住綁了沙網的一邊，對著塑膠管發出聲音（如圖三~七）。

   Level 2 - Hold the straw still on the net side and make sounds. Make the styrofoam balls move or jump with only sounds; then you pass Level-2.
3. 超越巔峰，玻璃杯可以發出美妙動人的音樂喔，想不想玩呢？

   Level 3 - Push the envelope. Make the glasses sing wonderful music. Wanna Try?

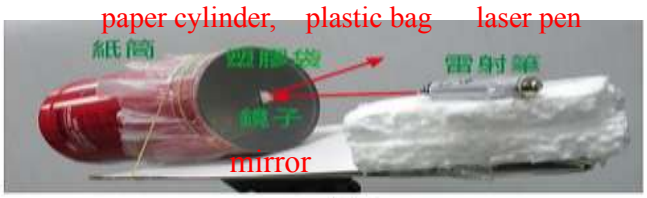
- **各關活動說明如下：**

第一關～哇~我看見聲音了！ Level-1 ~ Wow! I can see sounds!

過關標準：Tips 如圖一的裝置，利用雷射筆放出的光被反射在牆壁上，然後在紙筒後面發出聲音，就可以看到雷射筆反射的光點開始振動，光點的振動圖形隨著聲音的變化而變化（如圖二）只利用不同方式製造出聲音使其產生氣流，分別讓鏡子產生波動即可過關。

Level 1 - Use a device as shown in Picture-1 to reflect the light spot of the laser pen on the wall. Then make sounds from the other side of a paper cylinder. We can see the light spot of the laser pen start to vibrate and the shapes change with the sounds as in Picture-2. Use different ways to make soundwaves and make the shape vibrate; then you pass Level-1.

說明：Instruction



圖一

圖二

動腦時間：Brainstorming

1. 鏡子的大小是否會影響光點的振動？ Will the mirror size affect the vibration of light?

答：會！鏡子越大，質量也越大，在相
同的能量（聲音大小聲）的情形，
越不容易振動，會造成光點的振動
情形不明顯，因此鏡子不能太大。有些設計是以鋁箔紙取代鏡子，雖然更為簡便，但是鋁箔紙的反射效果不佳。

Ans：Yes! The bigger the mirror is, the larger its mass is, but the less the light spot vibrates under the same conditions (loud or silent). Thus, the mirror cannot be too big or the vibration of light would not be obvious. In other designs, tin foil will replace the mirror for convinience but with bad effects.

2. 聲音的大小聲（響度）、高低音（音調）不同時，對於光點的振動情形，分別有何影響？
How does the loudness and tone of sounds affect the vibration of light?

答：響度是聲音的「振幅」不同，越大聲振幅就越大。而音調是聲音的「頻率」不同，音越高振動頻率就越大。因此聲音越大聲會讓光點的振動幅度越大，而聲音越高讓光點的振動越快。為了要明顯看到光點的振動，建議製造大聲一點的聲音，比較有趣。另一方面，製造不同的高低音，讓學生觀察是否能察覺振動頻率是否有差別？

Ans：Loudness is the different amplitudes of sounds. Th louder the sound is, the greater the amplitudes of the soundwave. As for pitch, it is the audio frequency. The higher the pitch is, the higher the vibrating frequency is. Therefore, the louder the sounds are, the bigger the vibration amplitude is, whereas the higher the pitch is, the faster the vibration of light gets. We suggest students make louder sounds to see the vibration of light clearly. Besides, we also suggest students make different pitch to observe the differences of the vibration amplitude.

3. 光點的振動幅度，除了大小聲之外，還有其它因素嗎？ Are there other factors that affect the vibration amplitude of light besides volume?

答：有！雷射筆與鏡子的距離，還有與牆壁的距離都有關係。距離越遠，增加反射的距離，就有放大光點的振動幅度的效果。但是注意如果距離太遠，光點的亮度會降低喔！

Ans：Yes! The distance between the laser pen and the mirror and the wall also affects the vibration amplitude. The farther the distance is, the bigger the vibration amplitude of light is. But the farther the distance is, the dimmer the light spot will become.

第二關～聲音真的看得見！！ Level - 2 ~ Visualized Sounds

大朋友(高年級、國中) Grade 5-6 and Junior high Students

1. 取一支透明大吸管。在大吸管的一邊以膠帶將西卡紙黏貼封緊（如圖三）。然後將小保麗龍球（直徑約 0.2 公分以下）倒入大吸管中。最後將大吸管的另一邊，以一小片沙網套住，再以橡皮筋綁緊（如圖四）。

   Seal one side of a big transparent thick straw/tube with cardboard and tape. Then put styrofaom balls (less than 0.2cm in diameter) into the straw and cover the other side with net and a rubber band.

2. 操作方法為：雙手握住綁了沙網的一邊，對著塑膠管發出聲音（如圖四）。

   Hols the straw/tube still and make sounds toward the side with the net.

3. 注意：雙手與嘴巴必須密封，以使聲音可以完全進入塑膠管中。

   Remember to cover your mouth with the straw/tube entirely to make sure the sounds go into the tube completely.

圖三　圖四　圖五

圖六　圖七

發出聲音後，塑膠管中的小保麗龍球就會隨著聲音開始振動（如圖六），成為一片一片的波浪狀，甚至還會前後移動喔！

When making sounds, the little styrofoam balls in the straw/tube start to vibrate with the sounds in the shape of waves.

小朋友(中低年級) Grade 1-7

1. 首先在小紙杯的側邊以美工刀畫十字形，往內壓並張開，當為聲音輸入的開口，並在紙杯底部的上面放一小段毛根（圖八，摺成圓弧狀）。然後只要對著開口發出聲音（圖九），就可以看到毛根快速的旋轉起來喔！

   First cut and push to make a + shape opening on the side of a paper cup as the place to input the sound. Place the cup upside down and put a small piece of curly pipe cleaner on the top (the bottom side). Then make sounds toward the opening, you can see the pipe cleaner spin quickly.

2. 毛根的旋轉方向，與毛根上的細毛方向有關，而由於聲音產生空氣振動，進而使紙杯的振動傳達到毛根，轉而讓毛根運動了。另一方面，紙杯不能用大的紙杯，或是太硬的紙杯，因為紙質比較厚就不容易傳導振動，毛根的運動情形就不明顯了。

   The spinning direction of pipe cleaner relates to its hairs. The sound making the air vibrate in the cup also make the pipe cleaner move. However, do not use big cups, because thick paper conducts less vibration, making less movement.

圖八

圖九

過關標準：Tips 以嘴巴對大吸管發出聲音，使小保麗龍球就會隨著聲音開始振動就可過關(小朋友:使毛根可以在紙杯上旋轉)。

Make sounds toward the straw/tube and make the styrofoam balls moves with sounds.(Make the pipe cleaner spin, for young learners)

說明：Instruction 因為從大吸管(紙杯)中發出聲音的震動，改變了小保麗龍球四周(紙杯)原來相等的氣壓，使小保麗龍球(毛根)發生了震動。

Sound vibrations change the air pressure around the styrofoam balls (pipe cleaner) which was equally balanced making the balls (pipe cleaner) move.

動腦時間：Brainstorm

保麗龍球的數量會影響效果的明顯程度，太多或太少都不適合。建議倒入直立的塑膠管時，保麗龍球累積的高度，達到管子約三分之一高度即可。裝好保麗龍球之後，再搖動管子讓保麗龍球平均分散在管子中。另一方面，以嘴巴發出聲音時，避免吐出太多氣，因為塑膠管管壁會因水氣凝結而起霧，保麗龍球也會被沾濕。

The number of styrofoam balls affect the sound wave effect. Too many or too few balls leave less effect. One suggestion is to fill balls up to 1/3 of the tube and equally spread them after sealing the tube up. Another is to not breathe out too much air when making sounds. This will cause water molecules inside the tube to condense and moisten the tube wall and the balls.

進行教學時，可以指導學生探討以下問題與現象：

1. 發出不同高低的聲音時，保麗龍球的振動情形有何差異？
2. 製作不同長度的塑膠管，保麗龍球的振動情形有何差異？
3. 討論保麗龍球振動的明顯程度（振動大小），與聲音的大小聲有關，還是與聲音的高低有關？

During the teaching and learning, instruct the students to think about the questions：

1. Are there different vibrations of styrofoam balls when making sounds of different pitch?
2. Are there different vibrations of styrofoam balls when making tubes with different lengths?
3. Do styrofoam balls vibrations relate to loudness or pitches of sounds?

超越巔峰～玻璃音樂　Level – 3 ~ Wine Glass Music

1. 取一個高腳杯（玻璃杯），將手指頭沾濕以後，在高腳杯杯口邊緣摩擦（可以握住杯子底座，不可以握住杯口），看能不能發出聲音？注意：手指頭沾水可多不可少，而摩擦杯口時，以同一方向（順時鐘或逆時鐘皆可）摩擦，不必太用力（如圖十）。

   Wet one finger and rub the rim of the glass with it to see if you can make sounds. (Don’t hold on the body of the glass with the other hand. It’s ok to hold on the bottom.) Notice that moistening the finger with more water is fine but not

with too little water. When rubbing the rim, you can go one direction, either clockwise or counter-clockwiese. Remember not to rub the rim too hard.

2. 試一試不同大小的高腳杯，仔細聽一聽發出的聲音高低有何不同？(杯子越大，聲音越低)
   Try glasses of different sizes and listen carefully to the difference of the pitch of sounds. (The bigger the size of glass is, the lower the sounds are.)
3. 在同一個高腳杯加水，仔細聽一聽不同的水位高低，發出的聲音高低有何不同？(水加得越多，聲音越低)
   In the same glass, pour different amounts of water into it and hear the differences of the sound pitch. (The more water in the glass, the higher the sounds are.)
4. 利用不同大小的高腳杯以及加水多寡(如圖十一)，用調音器調出不同音階的杯子，就可以當成樂器「摸」出一首曲子喔。
   Make use of different sizes of glasses and different amount of water with a tuner to make different scales so that you can play a song with these instruments.

圖十

圖十一

過關標準： Tips 能讓每個杯子分別發出不同音高聲音。 Make different pitches with separate glasses

說明：手指頭在杯口摩擦時，能夠讓杯子產生震動(這種震動能夠由杯子裡的水產生波動觀察出來)，進而讓空氣振動而產生聲音。而杯子的質量越大，震動會越慢，因此杯子越大或是加了水，聲音都會變低。

如果發不出聲音經常是因為手沾的水不夠，或是摩擦得太輕或太重，多練習幾次一定可以成功。而加水太滿時，聲音的大小(響度)容易變小，因此調音時，需要調較低的音時，選用大一點的杯子會更好。另一方面，如果杯子質量相近(音高會接近)，則杯子本身越寬大，響度會越好。

Instruction: Rubbing the glass rim with a finger make the glass vibrate (we can observe the fluctuation of water in the glass), and make the air vibrate to make sounds. The bigger the mass of the glass is, the slower the vibration gets. Therefore, the bigger the size of the glass is or the more water the glass contains, the higher the sounds are.

The common reason why we cannot make sounds rubbing the glass rim is our finger is not wet enough or too light or too heavy we rub it. Usaually, after more practice, we can surely make sounds. When the glass contains too much water, the sounds easily get softer. Choose bigger glasses to make lower pitch sounds. Besides, when the mass of glasses are about the same, the bigger the sizes are, the louder the sounds are.