Sci A49 lab: Speed of sound from echoes

Spring 2001, 30 minutes. Comments to Alex Barnett, barnett@tornado.harvard.edu

Purpose: Estimating the speed of sound in air using the time delay of echoes from a nearby building.

Apparatus: Clapping device (2 pieces of wood strapped together at one end), stopwatch, meter rule.

Write-ups: Discuss within your group and fill in this worksheet as you go: give brief answers to the questions printed in bold.

Good locations near rm 305 in Science Center:
- Go further along corridor, outside on to patio (leave an object wedged in the door for re-entry). Stand on west side of patio and face east. Echo time is short here, but very clear.
- Same patio, climb up outside staircase, lean over south facing wall and face east towards central part of Science Center, which gives a longer echo time, but fainter.
- East entrance (modern) to Music Department, face east towards wall of Gordon McKay building. Avoid trees. Medium echo time.
- East side of Pierce, facing east towards wall of Museum buildings. Long echo time, clear.
- East side of Pierce, facing north to wall of new Microsoft building (Maxwell-Dworkin). Medium echo time, clear.
- South-west of Jefferson, facing south towards Littauer. Long echo time, clear.

1. Time measurement

Go outside in your groups and find a location at least a couple of dozen yards from a large, flat reflective surface of a building (see above box). Slap your wooden ‘clapper’ against your palm or thigh and see if you can hear the echo from the intended wall. You will hear other echoes coming from different directions too—try and concentrate on the desired one. Point the flat part of the clapper in the direction you want the sound to go (it radiates sound best out of the flat faces).

Set up a rhythm such that the echoes fall exactly between the claps. It will take a few attempts to be sure that the rhythm is ‘straight’ not ‘swung’ (in jazz parlance), i.e. not a ‘dotted rhythm’ (in classical parlance). Another of you time how long 10 or 32 or some convenient number of claps takes. **Record your results then swap roles and repeat. a) What is the average time per clap?**

2. Distance measurement

One of you count the number of paces from where you are to the wall, in a direction perpendicular to the wall. **Number of paces found:**
Back in the section meeting room, the pacing person now measures their pace on the meter rule. (They should walk by the rule while another records where their heel landed, and repeat a couple of times). **Length of pace:**

Calculate $L$, the distance to the wall:

3. Estimating the speed of sound

a) How far (in terms of $L$) does the sound travel in the time interval between a clap and its echo?

How far in the time between successive claps?

Use this latter distance in the relation

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

(1)

to estimate the speed of sound:

b) How accurate do you think you are? (This does not mean compare to the value in the textbook! Rather, think about errors in your distance and time measurements. Could you be accurate to $\pm 1$ m/s? $\pm 30$ m/s? $\pm 200$ m/s?)

Now you are equipped with a clapper (or you can clap your hands instead) and the speed of sound, you have basically **become a large, crude bat**, and can use sonar to ‘hear’ how far away large, reflective things are. Fortunately, unlike a bat, you do not have to rely on this to catch your next meal.