Board Meeting Beta:
Discovering the *Doppler Effect*

PHYSICS 204: MARTENS YAVERBAUM, KITAYAMA & WALTERS
JOHN JAY COLLEGE OF CRIMINAL JUSTICE, THE CUNY
LAB WEEK BEGINNING FRIDAY, MARCH 18, 2016

I. The Board Meeting PROCEDURES in general

Make certain to read ALL procedures before beginning to follow any of them.

1) Take at least one large white board for each group.

With as much clarity, completeness, color, vivacity and verity as possible,

On group white boards, respond to all the PROBLEMS.

You may certainly use more than one white board per group.

2) Leave AT LEAST 45 minutes to 1 hour for the following:

Gather in an approximate circle, all Boards facing in.

Discuss the Boards with respect to and for any leading questions posed by the Instructor.

The Instructor, however, will play a noticeably minimal role. Whenever s/he is silent and whenever you wonder what to discuss, do the following:

a) Begin by attempting to identify and reconcile disagreements among boards,

b) Freely but respectfully follow whatever conceptual/conversation paths emerge from the attempt to reconcile boards.

c) Emphasize Depth over Breadth:

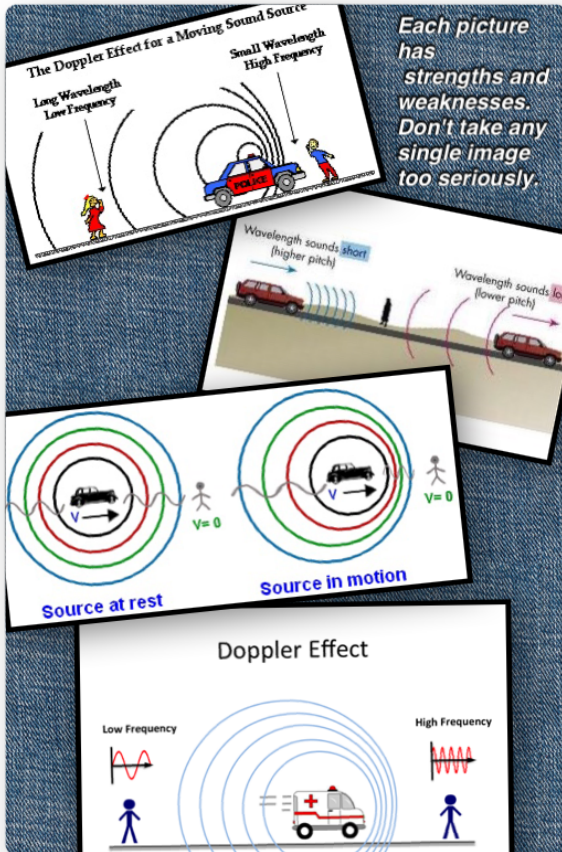
Once the class discovers that it is disagreement or confusion over a particular and fundamental point--

whether or not this point was originally intended for discussion--

STICK WITH THE CONCEPT PAST THE POINT OF FRUSTRATION & SEEMING 'CIRCLES'.

d) Do ***not*** interrupt colleagues.

e) Assuming you follow all the foregoing with rigor and respect, do ***not*** submit a lab report.



II. The *Doppler Effect* PROBLEMS in particular.

Look at the above images and any others you care to find.
Assume that SOUND is a wave – one which travels according to the same principles as the pulses we have been considering along a string.
Sound can travel in all 3 dimensions of space simultaneously, so it can ultimately involve some higher-level details than those along a string, but such details are not of concern here. We need only recognize that sound *propagates through a medium*; it does not move translationally as a distinct particle.

It's also, finally, helpful to recognize that our ear/brain interprets functions of the sound wave's amplitude as VOLUME and we, similarly,
interpret sound frequency as PITCH (like A sharp, B flat, etc.)

Past this, no further background with the Doppler Effect is assumed here of you.
You live in New York City; you've heard motorcycles pass by your building…

Figure stuff out!

You are expected to know what we have discussed in P204 lectures/labs regarding:

Angular Frequency, Angular Wavenumber, Period, Wavelength, Speed

AND

What we have discussed in P203 regarding:

The definition of average (and/or instantaneous) *velocity*,
Galileo's Principle of Relativity,

And how, in light of these fundamentals, physics treats
MOTION IN DIFFERING YET UNACCELERATED REFERENCE FRAMES.

From the above, anything and everything about the Classic 'Doppler Effect' for sound waves can be reasoned out; it's quite SIMPLE (though not easy) if you're careful and consistent.

CAUTION: The somewhat arbitrary sampling of images (above) seem,
On the whole, more helpful than not in providing a SENSE of what we're here considering.

But EVERY one of them includes AT LEAST ONE feature (generally in the labels) that is either mistaken, misleading or otherwise misfit for people who have gotten as far in their study of physics as you (believe it or not) have.
Yes: EACH ONE is 'WRONG' (though quite typical)
in some meaningful way or another.

So take the pictures for what they are, but be on the look-out for descriptions and explanations with which you are not entirely comfortable.

Observing and critiquing… and ARGUING the subtleties of representation
Are big essential elements of a productive Board Meeting.

So note and raise such concerns! Fully hash out what the pictures mean
BEFORE you get bogged down in numbers!

A. **THE PICTURES… to use then improve … !**

a. **Picture benefits.**

i. **From the pictures provided, as a group, come up with**
ii. **ONE COMPLETE (correct) ENGLISH SENTENCE COMPOSED OF YOUR (group's) OWN ORIGINAL WORDS that best captures what the Doppler Effect IS.**

Consider: (What is required for it to happen? What happens? Is it 'REAL' or an 'ILLUSION'?! In creating this ONE SENTENCE, you should find the pictures quite useful.

b. **Picture limitations → Improved by you**

i. **Find at LEAST ONE significantly misguided or misleading aspect of at least ONE of the pictures. Note as a group and be ready to explain.**
ii. **Provide A BETTER VERSION OF the picture you critiqued.**

B. **THE PROBLEM TO SOLVE… !**

The facts: A car is traveling on a non-windy day. It blares a horn. The car driver hears and MEASURES a frequency of 500 Hz. ***The car moves away*** from you at 44 m/s relative to air. Assume that sound travels at 340 m/s relative to air.

a. According to the car's measurements, what is the wavelength of the horn sound?

b. You also make measurements. Your equipment happens to be technologically advanced to precisely the same extent as that of the car. According to your measurements, what is the wavelength of the horn sound?

c. **According to your perspective, then, w**hat FREQUENCY is observed (heard) and measured in your frame of reference?

d. **Whose reference frame – yours or the car's -- is actually finding the truly correct numbers and Doppler realities? Which reference frame is the flawed one – the one getting tricked into frequency numbers that aren't really the ones which were sent?**

Is this a trick question?!
Does something actually 'CHANGE' on the way from one object ('source') toward the other? Or does some circumstance for a receiver at the end of the trip change?

e. **Receiver Approaching.**

f. Find the frequency you would observe if instead ***you*** were moving away from the car while ***the car was stationary*** relative to air (all above magnitudes held constant)

g. **Source Approaching**
Find the frequency you would observe if instead ***the car were moving toward you*** while ***you remained stationary*** relative to air (all above magnitudes held constant).

C. **BONUS/EXTENSION: Wind Blowing**

Find the frequency you would observe if you and the car were stationary relative to each other while a 44 m/s ***wind blew from the car to you***.

D. *** Some further and final hints … ***

The three key measurements with which we are most concerned are wave speed (of propagation), wavelength and frequency. Alll three together fit into one very simple relation (equation) – which does NOT involve derivatives or anything that sophisticated (although the relation can be DERIVED from a second-order differential equation, as you did in Lab #3).

The relation is simple, but you should make sure you have it and get it before you start playing around with numbers too much.

It's a relation that has the same simple form as, for example, F(net) = ma or y = mx. No tricks intended. But it's nonetheless tricky if you don't watch the concepts: For any given situation, always make sure to ask yourself: "WHICH OF THE THREE QUANTITIES IS BEING 'HELD' CONSTANT RIGHT NOW?" "WHY/HOW DOES IT MAKE SENSE TO ASSUME THIS CONSTANT?!"