TKU211122 Fluid, Heat & Waves
Homework #1 : Wave and Acoustic

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I. Problem #1 : Interference of 2 Sound Waves

II. Problem #2 : LIGO Interferometer

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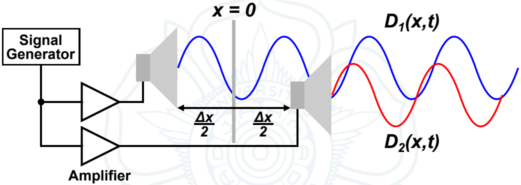
Homework #1

- Ini adalah Homework #1 dengan materi mengenai Perambatan Gelombang.
- Pengerjaan tugas ini **tidak boleh** diketik dengan komputer (harus menggunakan tulisan tangan), dan pengumpulan tugas ini akan dilakukan melalui *Google Classrom*. Pastikan bahwa tulisan pada pekerjaan anda **dapat terbaca dengan jelas** pada hasil *scan* atau foto yang anda unggah.
- Konversikan hasil *scan* atau foto pekerjaan anda menjadi *file* *.pdf.
- Berilah nama *file* adalah "FFKG_(Kelas A/B)_HW1_(6-digit NIU Anda)_(Inisial Nama Anda)". Sebagai contoh "FFKG_A_HW1_456789_DRU.pdf".
- Tetap Sehat dan Selamat Mengerjakan!

Problem #1 : Interference of 2 Sound Waves

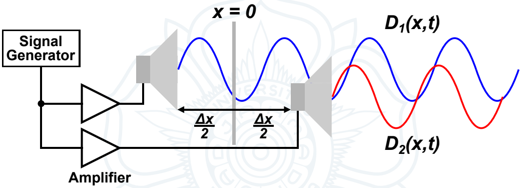


Two speakers are adopted to generate sinusoidal waves $D_1(x,t)$ and $D_2(x,t)$ with the same tone frequency ω. The waves $D_1(x,t)$ and $D_2(x,t)$ are defined as follows

$$D_1(x,t) = A_1 \sin[k(x - \Delta x/2) - \omega t + \phi_1]$$
$$D_2(x,t) = A_2 \sin[k(x + \Delta x/2) - \omega t + \phi_2]$$

The two speakers are placed at 2 different places separated by distance Δx. The sinusoidal signal is generated by the same signal generator as shown in the figure above. Two amplifiers are used to amplify the signal power generated from the signal generator before being sent to the speakers.

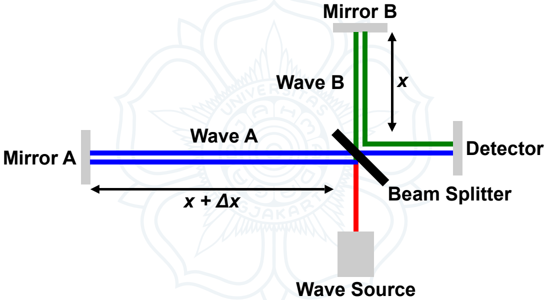
Problem #1 : Interference of 2 Sound Waves



Ideally, the two amplifiers should have identical characteristics. However, in reality, it is very difficult to have two perfectly identical amplifiers.

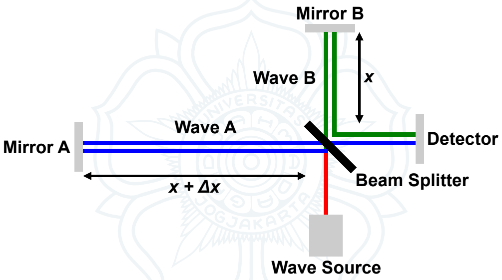
- (A) Suppose that the two amplifiers has different signal amplification such that $A_1 = A_o - \Delta A/2$ and $A_2 = A_o + \Delta A/2$. Determine the distance Δx_{min} and Δx_{max} for this case! Assume that $\phi_1 = \phi_2 = 0$!
- (B) Suppose that the two amplifiers has different phase shift such that $\phi_1 = -\phi_o/2$ and $\phi_2 = \phi_o/2$. Determine the distance Δx_{min} and Δx_{max} for this case! Assume that $A_1 = A_2 = A_o$!

Problem #2 : LIGO Interferometer



Interferometer is a device that adopts the concept of interference between two waves. Even though the basic principle is quite simple, this device is able to measure the difference in distance travelled by the two waves very accurately. Making use of its capability in performing an accurate measurement, an interferometer is then adopted in LIGO (Laser Interferometer Gravitational wave Observatory) for detecting the existence of gravitational waves.

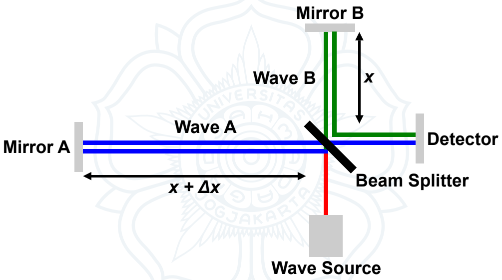
Problem #2 : LIGO Interferometer



The operating mechanism of an interferometer can be described as follows :

- A wave source (laser) produces a wave (light wave) with a specific wavelength.
- The wave then hits a beam splitter, a device that transmits 50% of the incident wave and reflects the other 50%. As the result, the wave is split into 2 different waves, Wave A and B.
- Wave A and B then propagate to Mirror A and B, respectively, and then they are reflected by the Mirrors.

Problem #2 : LIGO Interferometer

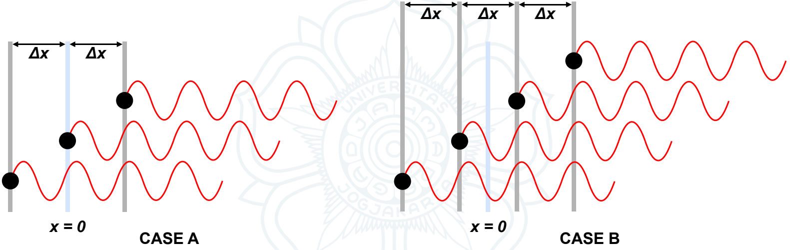


- The reflected waves then propagate back to the beam splitter.
- Finally, portion of the waves propagate to a detector, and then the superposition of the two waves can be detected by the detector.

Based on the wave intensity detected by the detector, the distance difference Δx between the mirrors and the beam splitter can be determined.

A. Determine the value of Δx_{min} and Δx_{max}, the distance Δx where the wave intensity at detector is minimum and maximum, respectively!

Problem #3 : Interference of Multiple Wave Sources



Let us consider two different cases when a system consists of 3 and 4 wave sources as shown in the figure above. Let us assume that all wave sources generate sinusoidal wave with the same amplitude and frequency.

- **A** Determine the amplitude and intensity of the resulting wave as a function of separation Δx ($A(\Delta x)$ and $I(\Delta x) = |A(\Delta x)|^2$)!
- **B** Plot a graph which shows the value of $I(\Delta x)$ as a function of Δx for $-3\lambda \leq \Delta x \leq 3\lambda$!

Problem #4 : Far Away Train and Fatamorgana

A student lives around 2.5 km from the closest railroad track. Even though the track is quite far from his house, he can still hear the sound of a train in the evening. He is wondering why this kind of phenomenon happens because he never hear the train sound from his house in the morning or afternoon.

A. Please explain to him the reason why can this kind of phenomenon happen?
B. Can the same explanation be applied to explain an optical phenomenon called Fata Morgana? Please explain your reasoning!