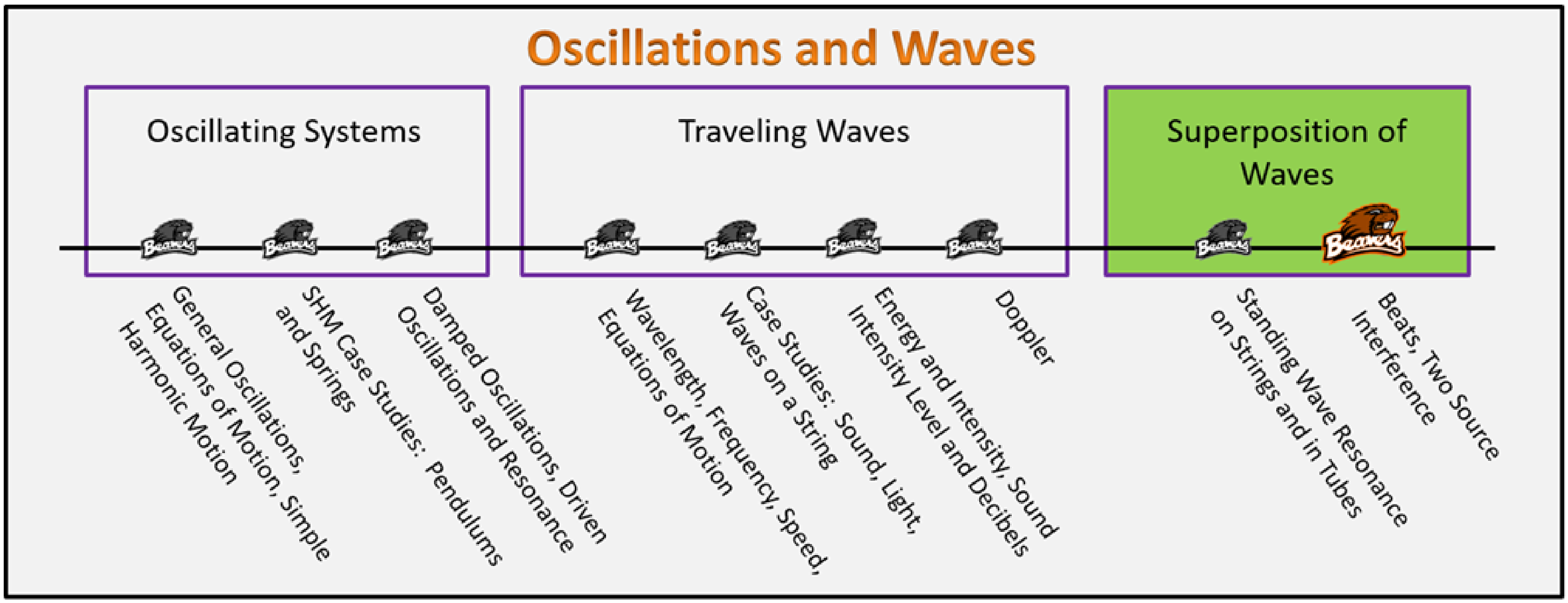
SW.L2.2.sols) Foundation Stage Solutions

Sunday, March 1, 2020 3:03 PM

Two Source Interference
Foundation Stage (SW.L2.2)

Lecture 2
Two Source Interference



Textbook Chapters (* Calculus version)

- **BoxSand** :: KC videos (Optics)
- **Knight** (College Physics : A strategic approach 3rd) ::
- ***Knight** (Physics for Scientists and Engineers 4th) ::

- **Giancoli** (Physics Principles with Applications 7th) ::

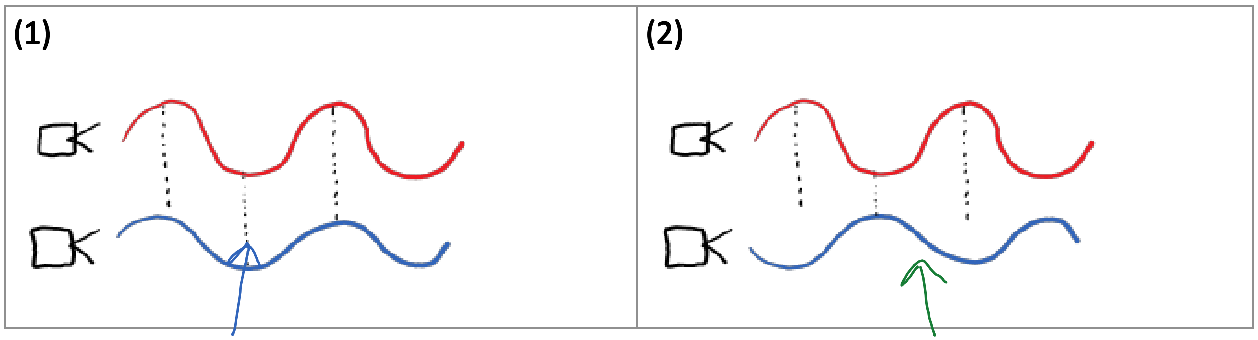
Warm up

SW.L2.2-1:

Description:

Learning Objectives: [?] - Can you identify the objectives from the previous lecture, and this lecture, that this question is relevant to?

Problem Statement: Which of these sets of speaker is "in phase"?



In phase

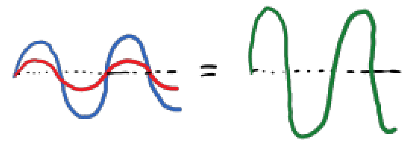
peaks line up with peaks (troughs with troughs)

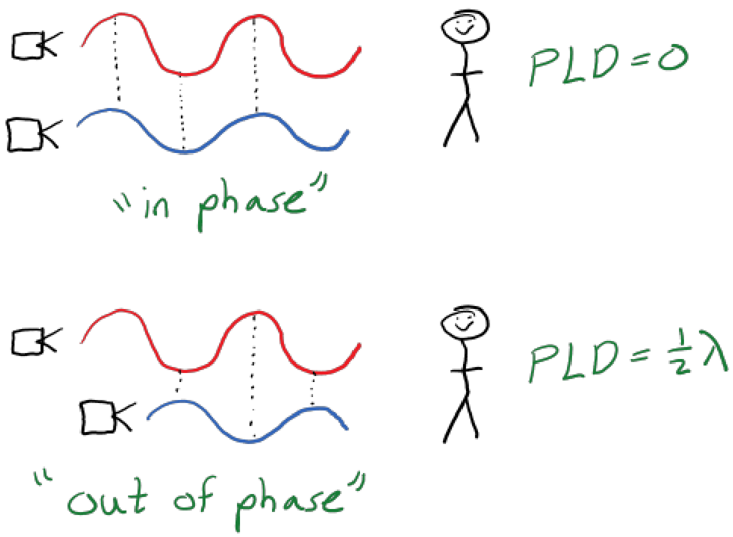
Out of phase

peaks line up with troughs

Interference – caused by waves entering same space at same time

Superposition – waves add linearly





constructive interference

sound – louder

light – brighter

Selected Learning Objectives

1. Coming soon to a lecture template near you.

Key Terms

- Path length difference
- Coherent
- Constructive

- Destructive

Key Equations

Constructive	Destructive
PLD = m λ	PLD = (m + $\frac{1}{2}$) λ

Key Concepts

- Coming soon to a lecture template near you.

Questions

Act I: Coherence

SW.L2.2-2:

Problem Statement: Many everyday objects produce multiple waves at the same time. These sources are said to be coherent if the waves they produce all have the same frequency. Which of the following can produce coherent waves?

(1) The sun

(2) **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation

(3) Incandescent Lightbulbs

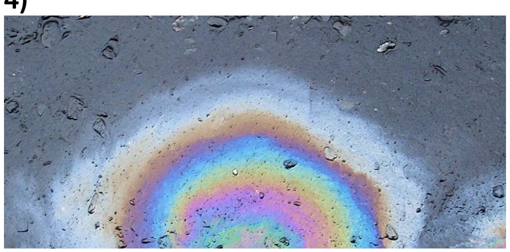
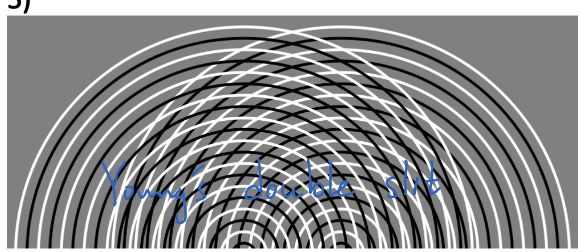
(4) Monochromatic LEDs

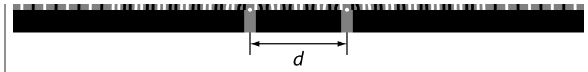
(5) Two speakers hooked to the same amplifier

(6) Speaker and tuning fork playing the same frequency

SW.L2.2-3:

Problem Statement: Which of the following images is displaying a wave interference effect?

1) 	**2)** 	**3)** 
4) 	**5)** 	



SW.L2.2-4:

Problem Statement: In order to exhibit spatial interference effects, which of the following statements must be true?

→ see picture 3 above

is it one or two waves?

1. Must have coherent sources
2. Sources must have the same power
3. Observer must stand still
4. Both sources must produce traveling waves
5. Only one wave is needed
6. Two or more waves are needed

Act II: Path Length Difference

SW.L2.2-5:

Problem Statement: Two sources separated in space …blah …blah …blah. Interference question.

(1) Density of the medium

(2) Ratio of the path lengths

(3) Path Length Difference

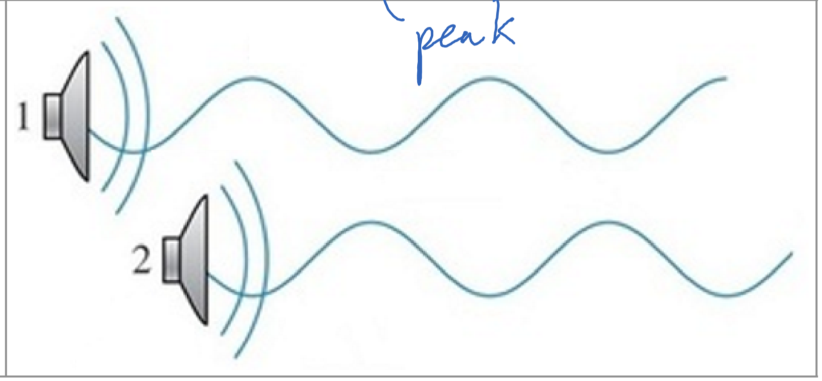
(4) 42 Hz

(5) Depends on what the wave tastes like

SW.L2.2-6:

trough

Problem Statement: Are the pictured speakers producing completely destructive interference, completely constructive interference, or somewhere in between?	

(1) Completely Constructive **(2)** Completely Destructive **(3)** Somewhere in-between	

SW.L2.2-7:

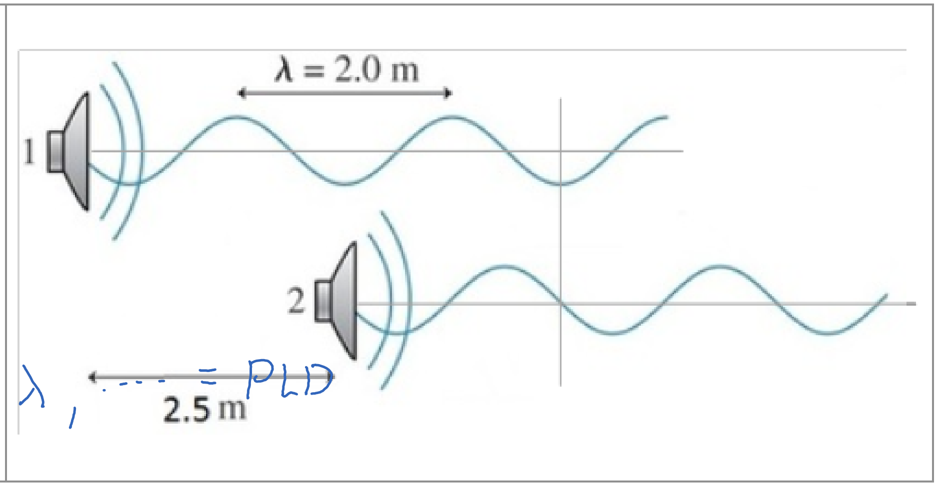
Problem Statement: Two loudspeakers emit (l = 2.0 m) waves that are emitted with the same phase. Speaker 2 is 2.5 m in front of speaker 1.	

(a) What, if anything, must be done to cause completely constructive interference between the two waves?

1. Move speaker 1 forward (to the right) 0.5 m.
2. Move speaker 1 backward (to the left) 1.0 m.
3. Move speaker 1 forward (to the right) 1.0 m.
4. Move speaker 2 backward (to the left) 0.5 m.
5. Move speaker 2 forward (to the right) 0.5 m.
6. Move speaker 2 forward (to the right) 1.0 m.
7. Move speaker 2 forward (to the right) 1.5 m.
8. Nothing. The situation shown already causes constructive interference.

$(m+\frac{1}{2})\lambda = PLD$

$\Rightarrow \frac{1}{2}\lambda, 1.5\lambda, 2.5\lambda, \cdots = PLD$



$\lambda = 2m \Rightarrow 1m, 3m, 5m, \cdots = PLD$

(b) What would need to be done in order to produce completely destructive interference?

⇒ move speaker 2: left 1.5 m, right 0.5 m, right 2.5 m, ···

or move speaker 1: left 0.5 m, right 1.5 m, right 3.5 m, ···

Act III: Mathematical Model and Application

SW.L2.2-8:

Problem Statement: Here are two different mathematical models used when determining extrema in two source interference. Match each to the appropriate type of interference.

1) $PLD = m\,\lambda$	A) Completely Constructive
2) $PLD = \left(m + \frac{1}{2}\right)\lambda$	B) Completely Destructive

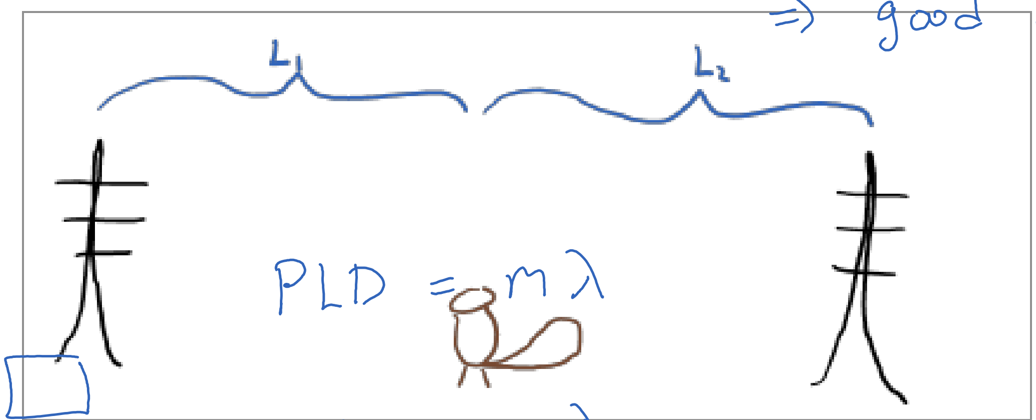
SW.L2.2-9:

Problem Statement: Benny is in his dam in the middle of the valley. On each side of the valley is a radio antenna that is broadcasting the racquetball championship (OSU is playing as they do every year). When Benny is holding his radio in his den, the radio is exactly at the midpoint between the two radio antennae.

(a) Does Benny get good or bad reception in his den?

$PLD = L_2 - L_1 = 0 \Rightarrow$ constructive interference

$\Rightarrow$ good reception



$\Rightarrow 0 = m\lambda$

$\Rightarrow m = 0$

(b) Thinking of the mathematical model for constructive interference, which value of m should we pick for the location of Benny's den?

1) 1
2) 2
3) 3
4) 4
5) 0

$v = f\lambda$

$$\lambda = \frac{v}{f} = \frac{3 \times 10^8 \text{ m/s}}{15 \times 10^6 \text{ Hz}} = \frac{10^2}{5} \text{ m} = 20 \text{ m}$$

(c) If the frequency is 15 MHz, what is the wavelength of the radiation?

(Hint: the speed of light in air is 2.998 x 10^8 m/s, and the speed of sound in air is 343 m/s)

good reception => constructive interference

good reception

(d) Benny walks from his den to his kitchen and then into his bedroom. Assume this is a straight line towards one of the antennae. Assume that he is also carrying his radio for some reason!

He notices the reception is good in the den and the bedroom, but it was poor in the kitchen. Which mathematical model would you use to analyze the interference in the bedroom?

1) $PLD = m\,\lambda$	2) $PLD = \left(m + \frac{1}{2}\right)\lambda$

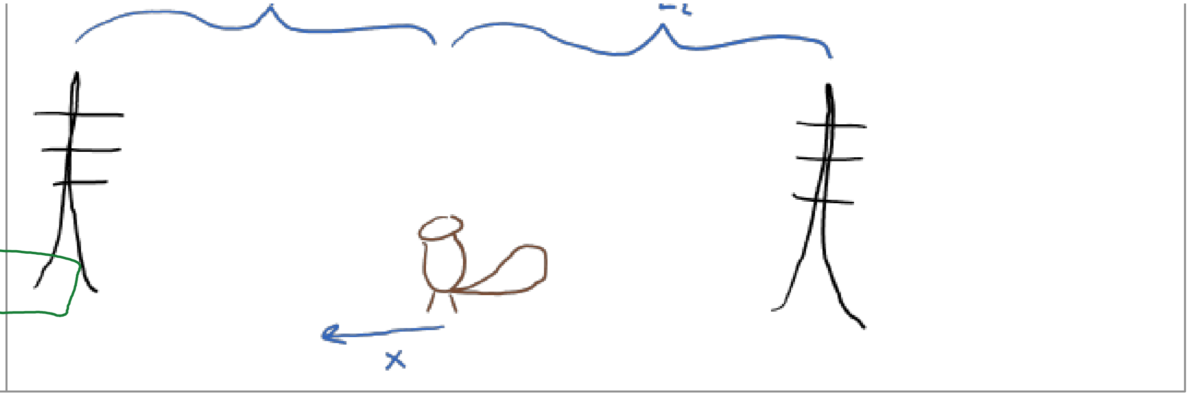
$PLD = m\lambda$

$m = 0, 1, 2, \ldots$

$m = 1$

(e) RHS: What m-value should we use for the mathematical model of the interference in the bedroom?

1) 1	L_1 L_2

2) 2 **3)** 3 **4)** 4 **5)** 0	

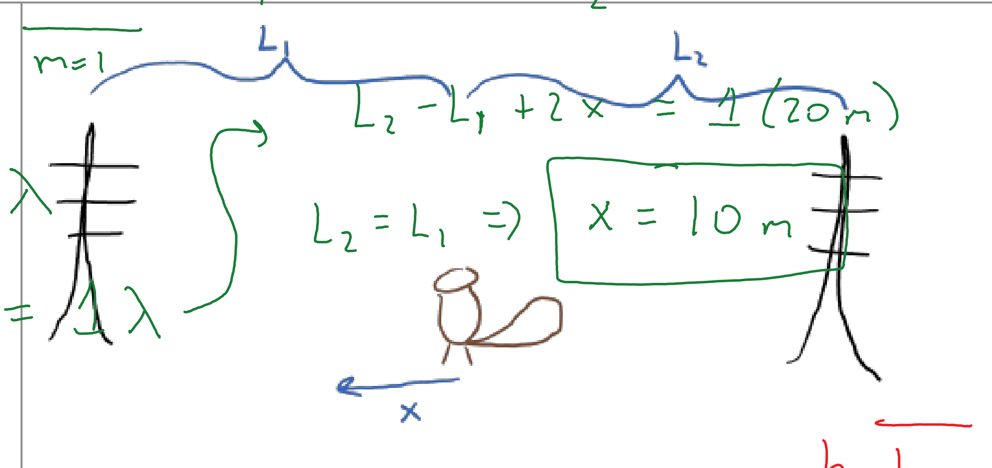
also could work with negative m!

$PLD = PL_2 - PL_1$

$L_1 - x \Rightarrow PL_1$

$L_2 + x \Rightarrow PL_2$

(f) LHS: Which expression could we use for the PLD when Benny is in the bedroom?

1) $(L_1 - x) - (L_2 - x)$ **2)** $(L_1 - x) - (L_2 + x)$ **3)** $(L_2 + x) - (L_1 - x)$ **4)** $(L_1 + x) + (L_2 + x)$	

$PLD = m\lambda$

$(L_2 + x) - (L_1 - x) = 1\lambda$

$L_2 - L_1 + 2x = 1(20\,m)$

$L_2 = L_1 \Rightarrow x = 10\,m$

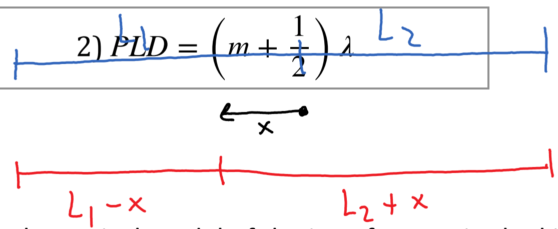
bad reception $\Rightarrow$ destructive interference

(g) How far is it from the den to the bedroom?

Smallest PLD that produces destructive interference

(h) Now consider the kitchen. Which mathematical model would you use to analyze the interference in the kitchen?

1) $PLD = m\,\lambda$	2) $PLD = \left(m + \frac{1}{2}\right)\lambda$



(i) RHS: What m-value should we use for the mathematical model of the interference in the kitchen?

$PLD = (L_2 + x) - (L_1 - x)$

1) 1
2) 2
3) 3
4) 4
5) 0

$PLD = \left(m + \frac{1}{2}\right)\lambda$

$(L_2 + x) - (L_1 - x) = \left(0 + \frac{1}{2}\right)(20\,m)$

(j) LHS: Which expression could we use for the PLD when Benny is in the kitchen?

1) $(L_1 - x) - (L_2 - x)$

$L_2 - L_1 + x + x = \frac{1}{2}(20\,m)$

2) $(L_1 - x) - (L_2 + x)$

$0 + 2x = 10\,m$

3) $(L_2 + x) - (L_1 - x)$

$x = 5\,m$

4) $(L_1 + x) + (L_2 + x)$

(k) How far is it from the den to the kitchen?

Conceptual questions for discussion

1. Coming soon to a lecture template near you.

Hints

TW.2.L1-1: No hints.

TW.2.L1-2: No hints.

TW.2.L1-3: No hints.

TW.2.L1-4: No hints.

TW.2.L1-5: No hints.

TW.2.L1-6: No hints.

TW.2.L1-7: No hints.

TW.2.L1-8: No hints.

TW.2.L1-9: No hints.

TW.2.L1-10: No hints.

TW.2.L1-11: No hints.

TW.2.L1-12: No hints.

TW.2.L1-13: No hints.