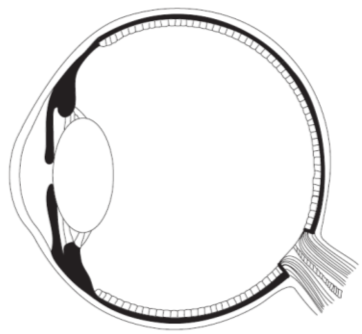
Name: ____ Date: ______________________ Period: _________

IB Physics SL Y2 – Option A (Sight and Wave Phenomena Part 1) – Midterm Exam Study Guide
Exam Date: Thursday, March 12, 2015

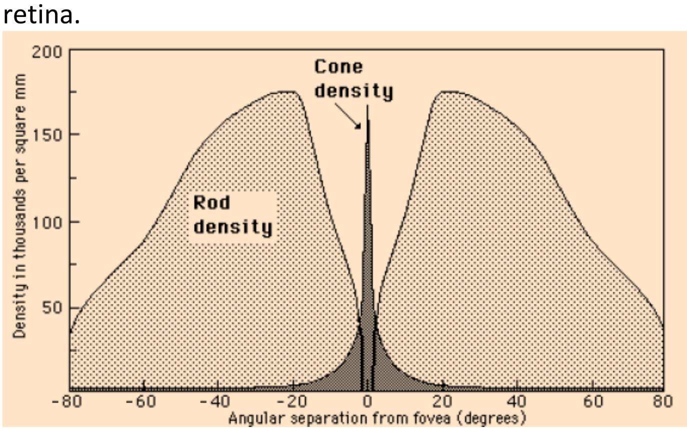
Objectives:

A.1.1 Describe the basic structure of the human eye.



A.1.2 State and explain the process of depth of vision and accommodation.

A.1.3 State that the retina contains rods and cones, and describe the variation in density across the surface of the retina.



A.1.4 Describe the function of the rods and of the cones in photopic and scotopic vision.

A.1.5 Describe color mixing of light by addition and subtraction.

A.1.6 Discuss the effect of light and dark, and color on the perception of objects.

A.2.1 Describe the nature of standing (stationary) waves.

A.2.2 Explain the formation of one-dimensional standing waves.

A.2.3 Discuss the modes of vibration of strings and air in open and in closed pipes.

A.2.4 Compare standing waves and travelling waves.

A.2.5 Solve problems involving standing waves.

A.3.1 Describe what is meant by the Doppler effect.

A.3.2 Explain the Doppler effect by reference to wavefront diagrams for moving-detector and moving-source situations.

A.3.3 Apply the Doppler effect equations for sound.

A.3.4 Solve problems on the Doppler effect for sound.

A.3.5 Solve problems on the Doppler effect for electromagnetic waves using the approximation.

A.3.6 Outline an example in which the Doppler effect is used to measure speed.

Formula Sheet:

Speed of light in a vacuum c 3.00×10^8 ms^{-1}

$$f' = f\left(\frac{v}{v \pm u_s}\right)$$ moving source

$$f' = f\left(\frac{v \pm u_o}{v}\right)$$ moving observer

$$\Delta f = \frac{v}{c} f$$

Practice Problems:
Assume the Speed of Sound in air as 340ms^{-1} (if it is not provided)

Standing Waves

1. Alternating current is passed along a 1.5 m length of wire stretched at constant tension between two fixed points. The wire passes between the poles of a horseshoe magnet at its centre. When the frequency of the alternating current is adjusted to 85 Hz, the wire vibrates with three antinodes along its length.
   a. Sketch the pattern seen.
   b. How does the phase vary along the wire compared with the midpoint?
   c. Calculate the wavelength and the wave speed of the waves on the wire.

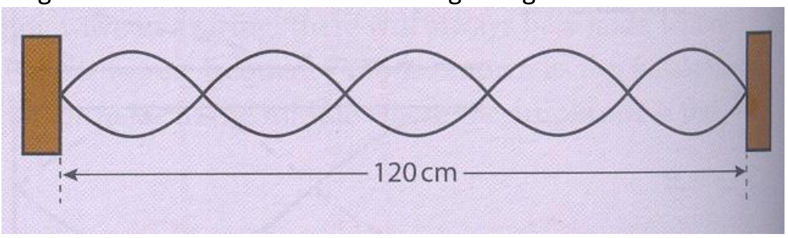
2. A small loudspeaker is placed near the open end of a pipe of length 400mm closed at its other end. The minimum frequency at which the pipe resonates is 215 Hz.
   a. Estimate the speed of sound in the pipe.
   b. Calculate the next frequency for resonance.

3. A church organ consists of open-ended pipes of differing lengths. The minimum length is 30 mm and the longest is 4.0m. Given the speed of sound in air is 340ms^{-1}, estimate the frequency range of the fundamental notes.

4. A vertical pipe that is open-ended at its upper end is connected to a water tap at its lower end. The length of the column in the pipe can be varied by raising or lowering the level of water in the pipe. A tuning fork of frequency 342 Hz is sounded and then held with its vibrating tips over the open end of the pipe. At the same time, the water level is gradually lowered from the top. The air column in the tube resonates when its length is 245 mm then again when its length is 735 mm. Calculate the speed of sound in the tube.

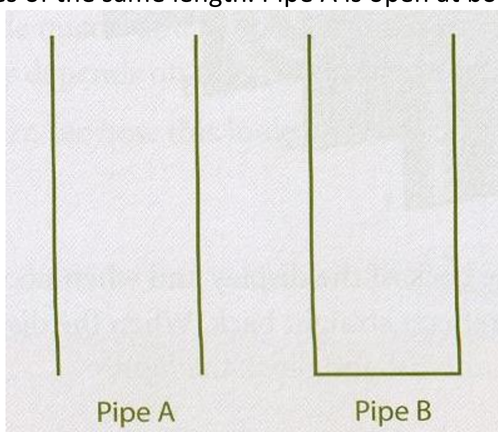
5. Stationary waves are set up all a wire vibrating at a frequency of 438 Hz such that the distance between adjacent nodes is 45 cm. Calculate the wavelength and speed of the waves on the wire.

6. By reference to energy transfer and the amplitude of vibration of particles in a wave, distinguish between a travelling wave and a standing wave. A stretched string is fixed at both ends and then plucked at its center. The diagram below illustrates the vibrating string. The distance between the fixed points is 120cm.



   a. Find the wavelength of the standing wave.
   b. The frequency of vibration of the string is 250 Hz. Determine the speed of the tuning fork, frequency 256 Hz wave on the string.

7. The diagram below shows two pipes of the same length. Pipe A is open at both pipe B is closed at one end.



   a. On the diagrams above,
      i. draw lines to represent the waveforms of fundamental (first harmonic) resonant note for each pipe.
      ii. label the position of the nodes with the letter N position of the antinodes with the letter A.
   b. The frequency of the fundamental note for pipe A is 512 Hz.
      i. Calculate the length of the pipe A. (Speed of sound in air =325ms^{-1})
      ii. Suggest why organ pipes designed to emit low frequency fundamental *(e.g.* frequency 32 Hz) are often closed at one end.

Doppler Effect

8. The predominant frequency of a certain police car's siren is 1600 Hz when at rest. What is the detected frequency if the car is
   a. moving toward an observer at 25 ms^{-1}, and
   b. if moving away at the same speed?

9. In one of the original Doppler experiments, one tuba was played on a moving platform car at a frequency of 75 Hz, and. a second identical one was played on the same tone while at rest in the railway station. What beat frequency was heard in the train if the train approached the station at a speed of 10.0 m/s?

10. Two trains emit whistles of the same frequency, 277 Hz. If one train is at rest and the other is travelling at 40 km/hr away from an observer at rest, what beat frequency will the observer detect?

11. Two cars are equipped with the same single-frequency horn. When one is at rest and the other is moving towards an observer at 15 ms^{-1}, a beat frequency of 5.5 Hz is heard. What is the frequency the horns emit?

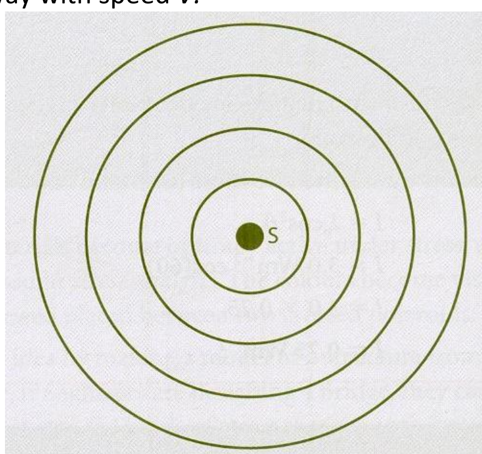
12. Compare the shift in frequency if a 2 kHz source is moving toward you at 15 ms^{-1} versus if you are moving toward it at 15 ms^{-1}. Are the two frequencies exactly the same? Are they close? Repeat the calculation for 150 ms^{-1} and then again for 300 ms^{-1}. What can you conclude about the asymmetry of the Doppler formulas?

13. Waves of frequency f and speed c are emitted by a stationary source of sound. An observer moves along a straight line towards the source at a constant speed v. State, in terms off, ***c*** and ***v,*** an expression for
    a. the wavelength of the sound detected by the observer
    b. the apparent speed of the wave as measured by the observer.

14. A car is initially at rest with its radio playing music. There is a musical note of frequency 440 Hz spreading out form the car. The speed of sound in air is 330 ms^{-1}
    a. Calculate the
        i. distance between the wavefronts
        ii. frequency of the note as heard by an observer standing some distance in front of the car
    b. The car now moves at constant speed, ***v,*** towards the observer with the radio still playing. At what speed are the wavefronts progressing towards the observer?
    c. If the speed of the car is 8.00 ms^{-1}, calculate
        i. the distance between the wavefronts that approach the observer
        ii. the frequency of the note as heard by the observer.

15. A star is moving away from the Earth at a speed of 3.0 x 10 ms^{-1}. If the light emitted from the star has a frequency of 6.0 x 10^{14} Hz, find the wavelength shift observed on Earth.

16. The diagram below shows wavefronts produced by a stationary wave source spacing of the wavefronts is equal to the wavelength of the waves. The way with speed *V.*



    a. The source S now moves to the right with speed in the space below draw *four* successive wavefronts to show the pattern of waves produced by source.
    b. The Sun rotates about its center. The light from one edge of the Sun, as a stationary observer, shows a Doppler shift of 0.004 nm for light of wavelength 600.000 nm. Assuming that the Doppler formula for sound may be used for light, estimate the linear speed of a point on the surface of the Sun due to its rotation.