APPENDIX 1: WAVES

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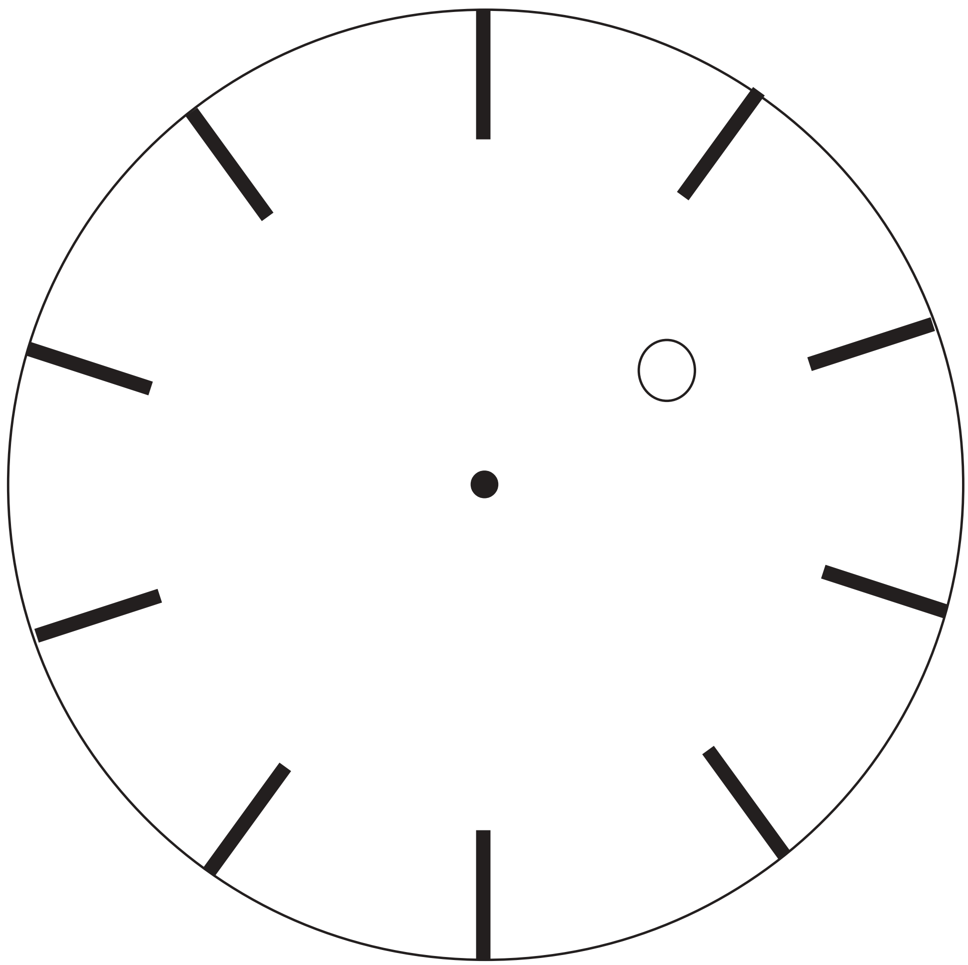
Appendix 1.1: Strobe Template

The hand stroboscope can be used to determine the frequency of an object with repetitious motion. By rotating the stroboscope and looking through the open slits, the experimenter can make the object appear at the same position at all times. This gives the illusion that the object is stopped. Experiment to determine the combination of open slits and frequency of the stroboscope required to “stop” the object. The number of slits can easily be changed by taping every second slit.



Strobe Student Activity

Calculate the frequency of a vibrating object using:

Frequency of object = stroboscope frequency x number of open slits

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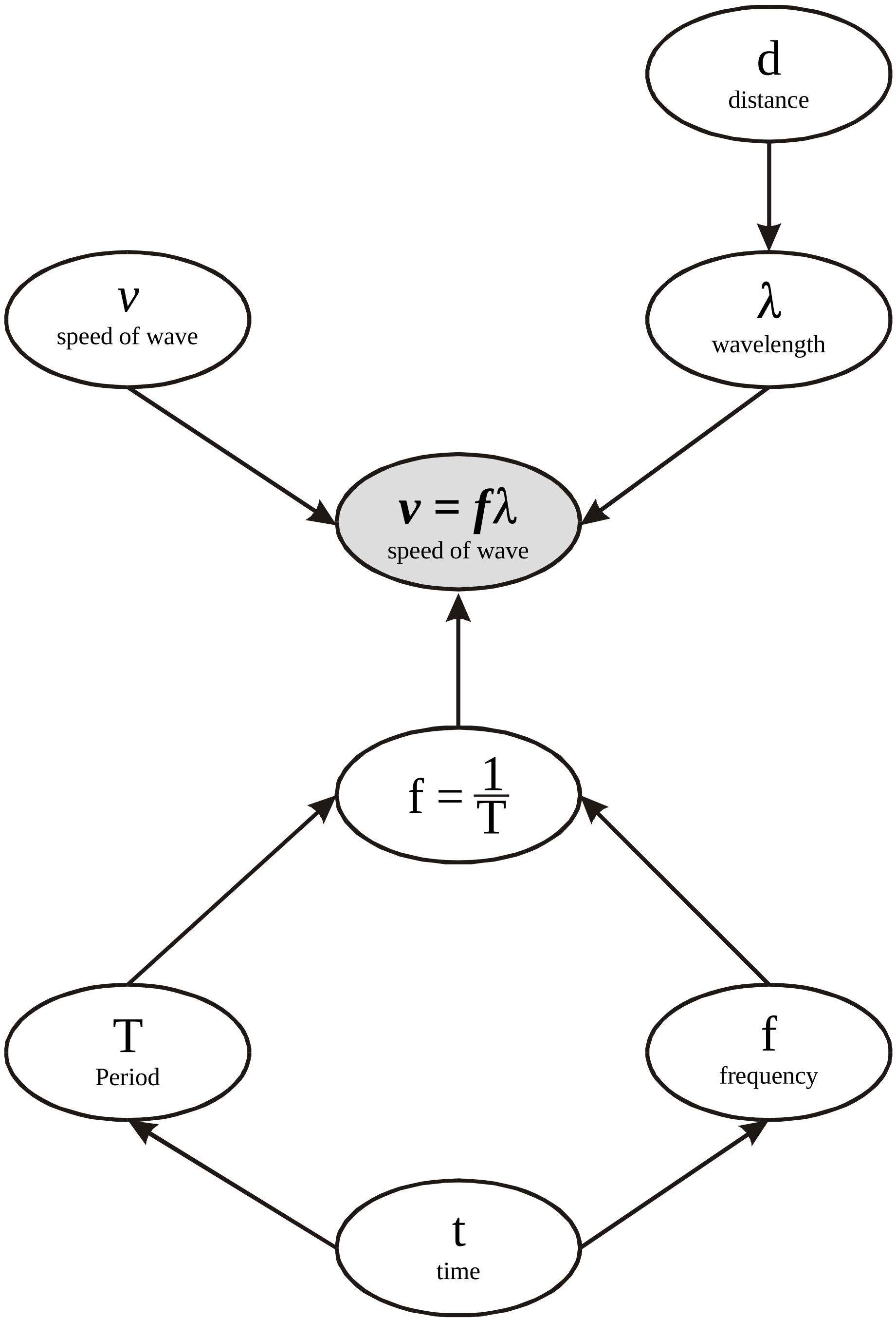
Appendix 1.2: Concept Map for Wave Equation Variables

Concept Map: Students will identify variables for the universal wave equation and see how they are related. (Specific Learning Outcome 1.1.4.)



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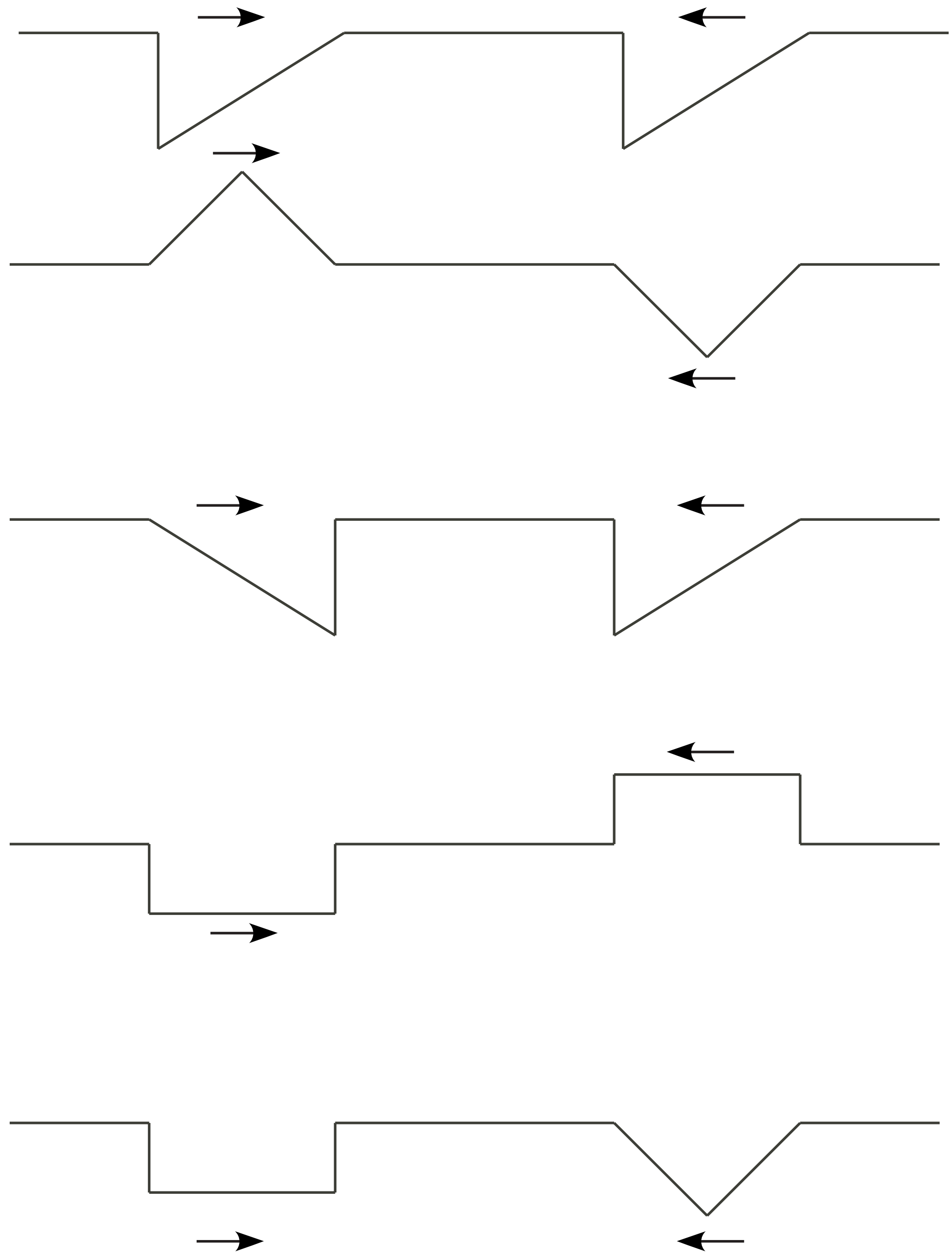
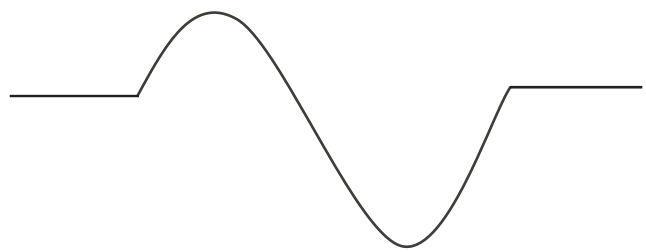
Appendix 1.3: Superposition of Waves

1. Draw the superimposed pulse when point **A** coincides with point **B**.
   Note: You must draw in point A and point B on each diagram.

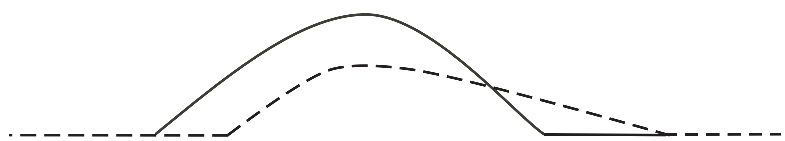


2. Draw a pulse moving to the left that would momentarily cancel the given pulse when they meet.

3. Draw a pulse moving to the left that would pass through the given pulse without the midpoint, M, moving.



4. Draw in the resultant wave.



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Appendix 1.4: Waves in One Dimension

1. Define the following terms:
   a) wavelength

   b) amplitude

   c) transverse wave

   d) frequency

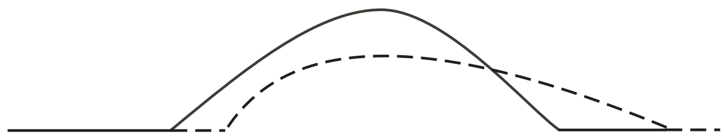
   e) node

   f) rarefaction

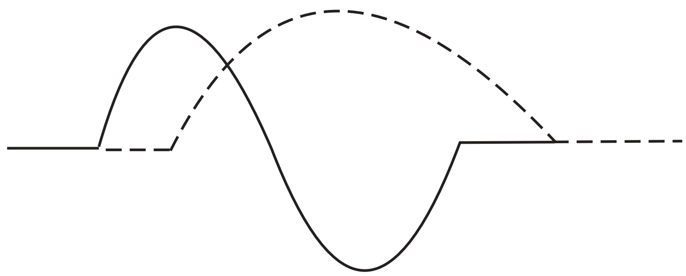
2. What is a wave?

3. Draw in the resultant wave.

   a)



   b)



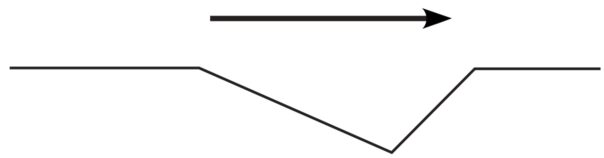
4. Using diagrams, indicate what occurs if a wave travelling on a spring meets each of the following junctions. Include a description of each transmitted pulse and each reflected pulse.

   a) a fixed end

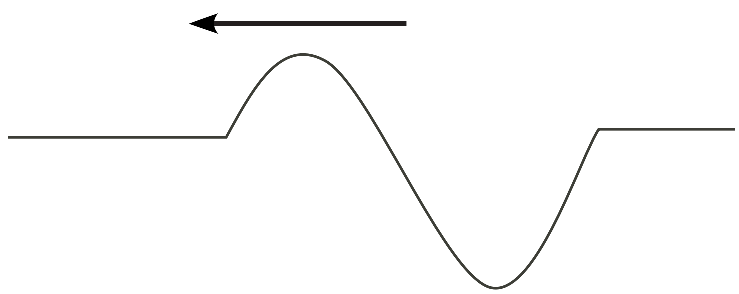
   b) a junction between a heavy and a light spring

   c) a junction between a light and a heavy spring

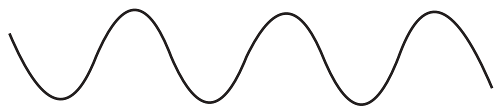
5. Draw a wave pulse moving to the left that will momentarily cancel the given pulse.



6. Draw in the wave pulse moving to the right that will pass through the given pulse without causing M, the midpoint, to move.



7. The picture below shows a segment of a string along which a transverse wave is moving.



Based on this picture, what is

a) the wavelength of this wave?

b) the amplitude of this wave?

c) the frequency of the wave if it took 0.28 s for the given waves to pass by a point?

8. What is the speed of a wave with a wavelength of 0.27 metres and a frequency of 7.5 Hz?

9. A transverse wave is moving along a string. What is the period of this wave if it has a wavelength of 0.45 metres and a propagation speed of 22 m/s?

10. A woman is fishing from a stationary rowboat in the middle of a lake. A speedboat starting up 7.5 metres away from the rowboat sends out waves with a speed of 0.85 m/s and a frequency of 0.95 Hz.

a) What is the wavelength of these waves?

b) How many wavelengths would fit into the distance between the speedboat and the rowboat?

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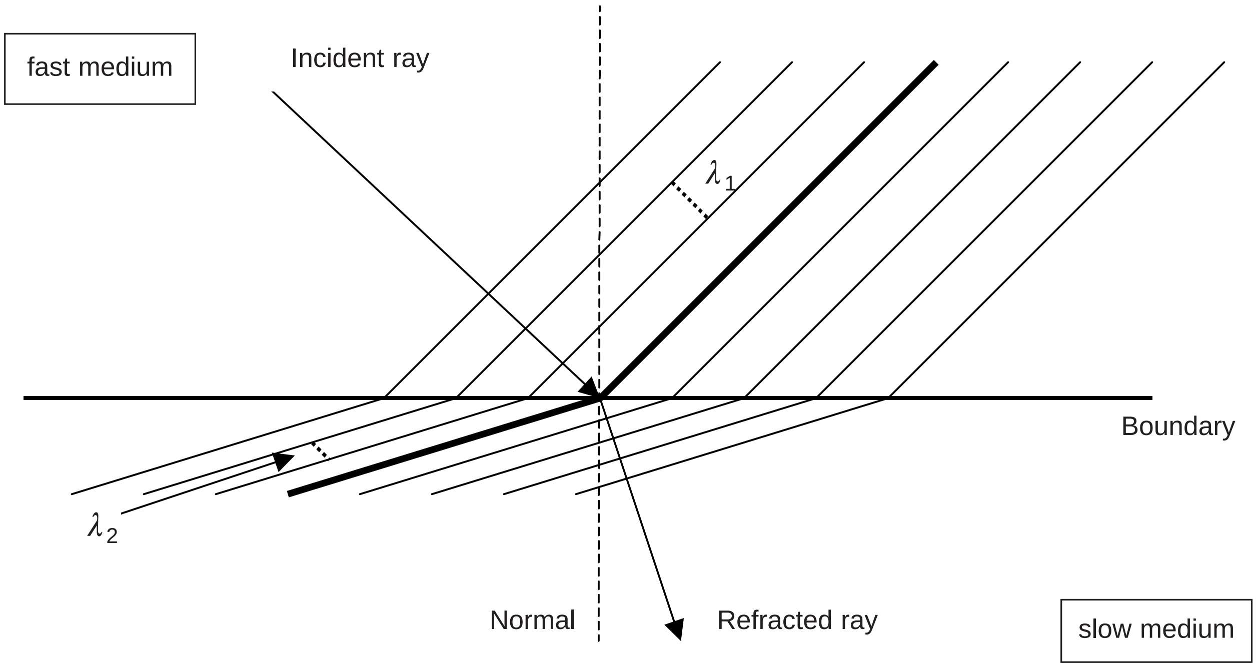
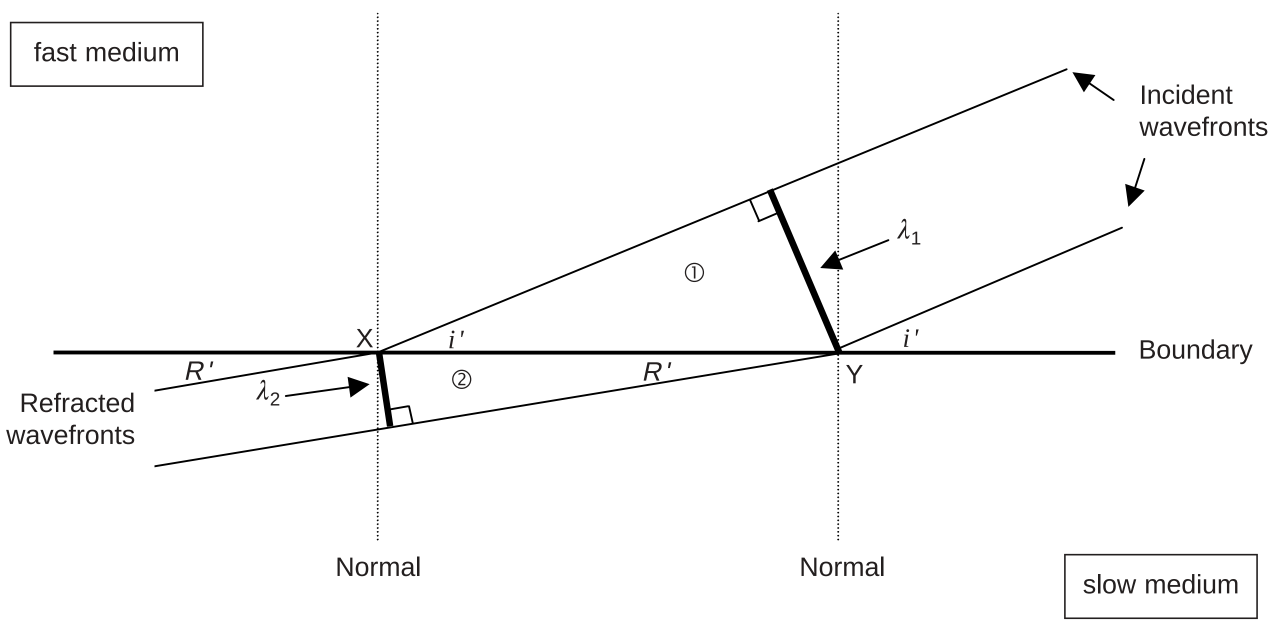
Appendix 1.5: Derivation of Snell's Law

The diagram represents the incident and refracted wavefronts and wave rays. As the wavefront passes from the fast ("lighter") medium to the slow ("heavier") medium, the wavefront slows down and bends.

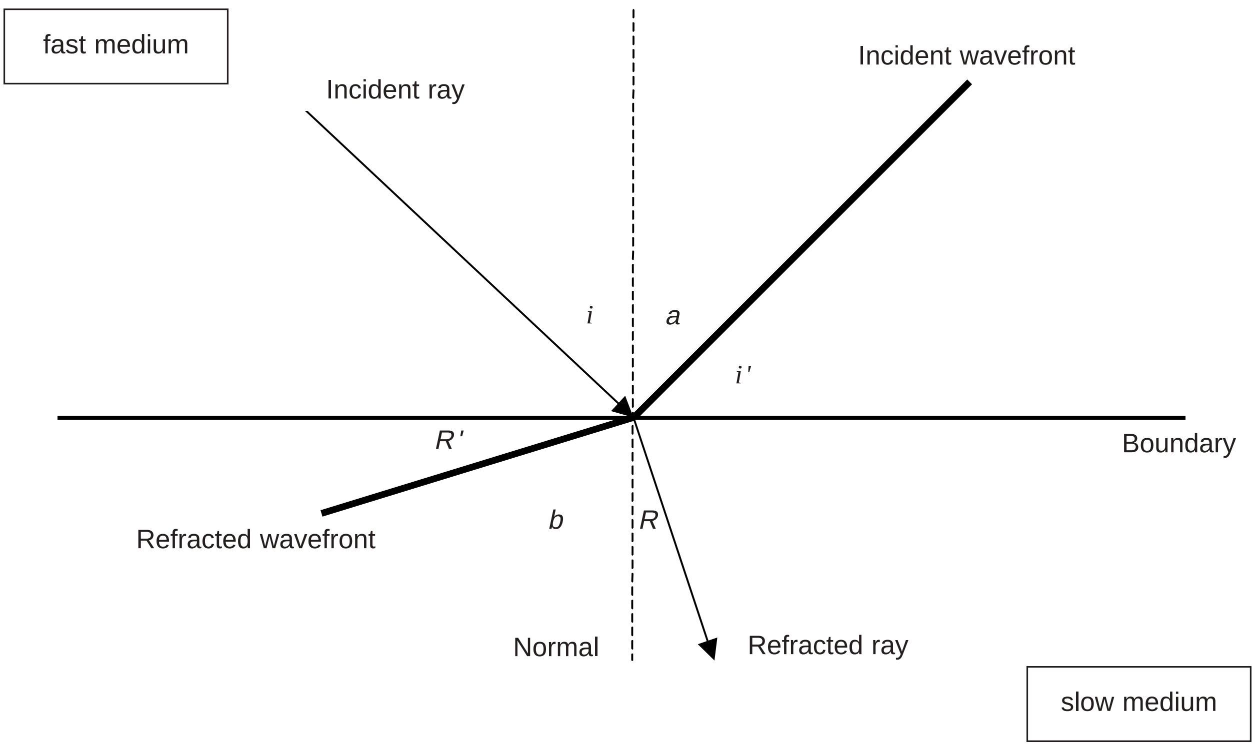
Consider the wavefronts.





1. In triangle 1: $\sin i' = \dfrac{\lambda_1}{XY}$
2. In triangle 2: $\sin R' = \dfrac{\lambda_2}{XY}$
3. Solve for $\overline{XY} = \dfrac{\lambda_1}{\sin i'} = \dfrac{\lambda_2}{\sin R'}$
4. Therefore: $\dfrac{\sin i'}{\sin R'} = \dfrac{\lambda_1}{\lambda_2}$
5. Since $v \alpha \lambda$, then $\dfrac{v_1}{v_2} = \dfrac{\lambda_1}{\lambda_2}$
6. Therefore: $\dfrac{\sin i'}{\sin R'} = \dfrac{v_1}{v_2}$

In terms of the wave ray:



Since the wave ray and wavefronts are perpendicular: $i + a = 90°$.

Since the normal and boundary are perpendicular: $a + i' = 90°$.

Therefore, $i + a = a + i'$.

And: $i = i'$.

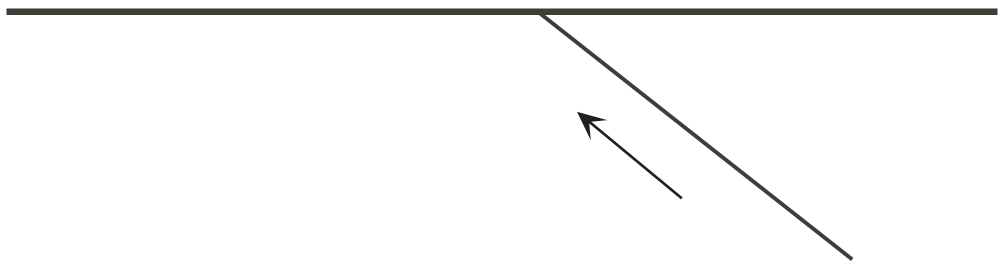
Similarly, $R = R'$.

Snell's Law states that the ratio of the sines of the incident and refracted angles are constant.

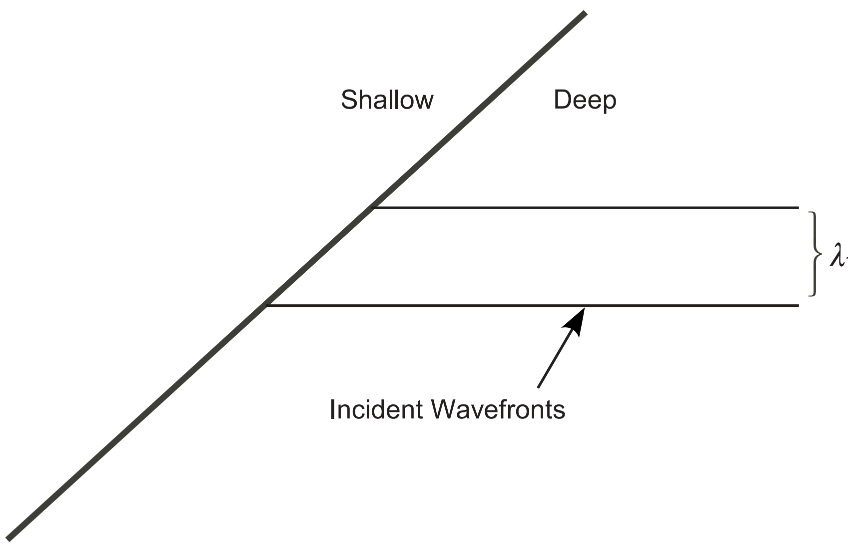
$\dfrac{\sin i}{\sin R} = {}_1n_2$ where ${}_1n_2$ is called the index of refraction.

Working with Snell's Law and Wavefronts

1. Draw in the reflected wave ray. Indicate clearly the direction of motion, the angle of incidence, and the angle of reflection.



2. The diagram below represents a ripple tank with deep and shallow water. Waves in deep water travel up the page towards the boundary with shallow water, as illustrated below. The frequency of the wave is 8.50 Hz. In deep water, the waves travel at 9.0 cm/s. Diagram is drawn to scale.



a) Draw in the ***direction of motion*** and the ***angle of incidence***.

b) Determine the ***relative index of refraction*** at the shallow-deep surface.

c) Determine the ***angle of refraction*** in deep water.

d) Draw in the two ***refracted*** wave crests in the deep water.

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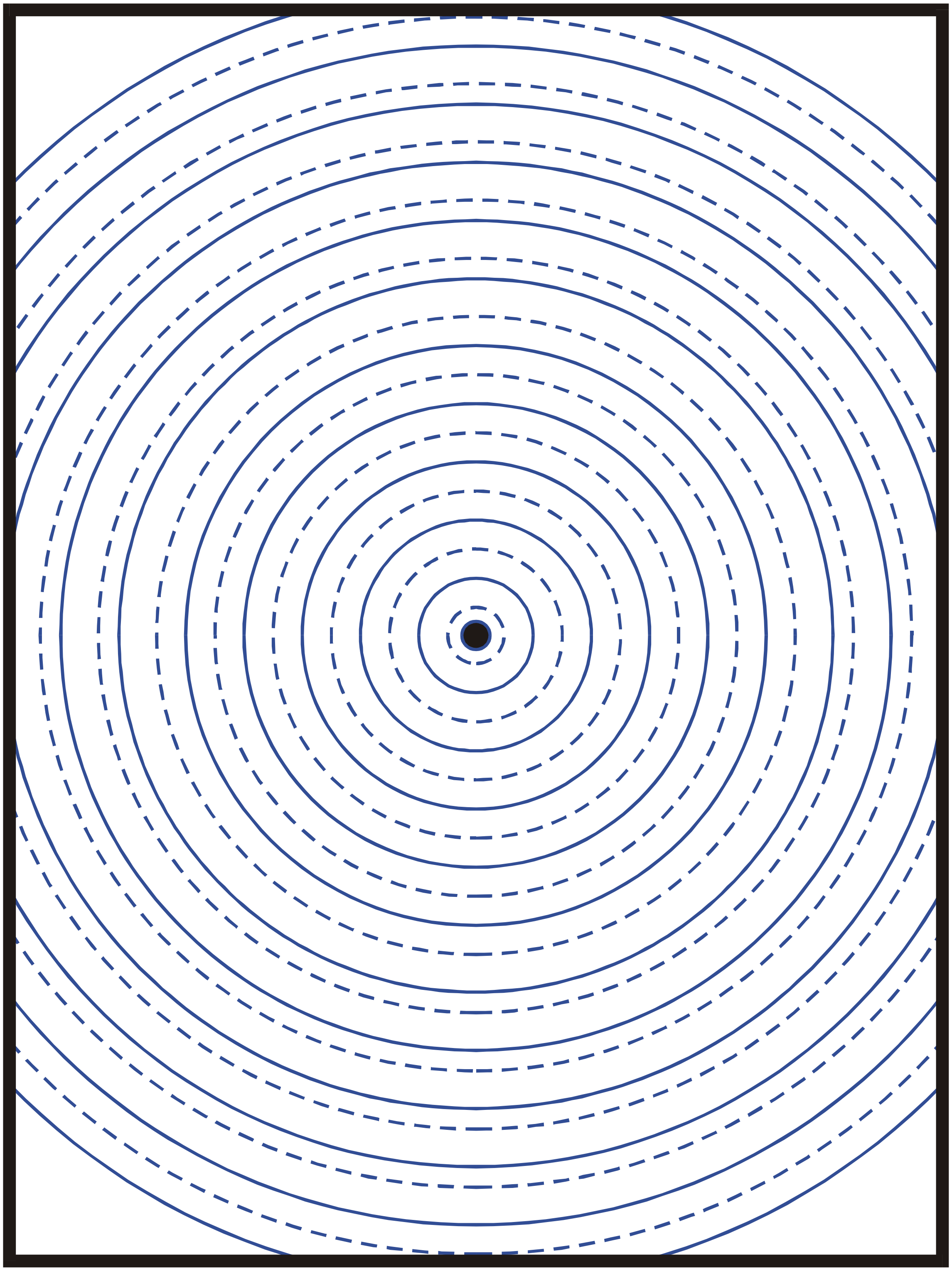
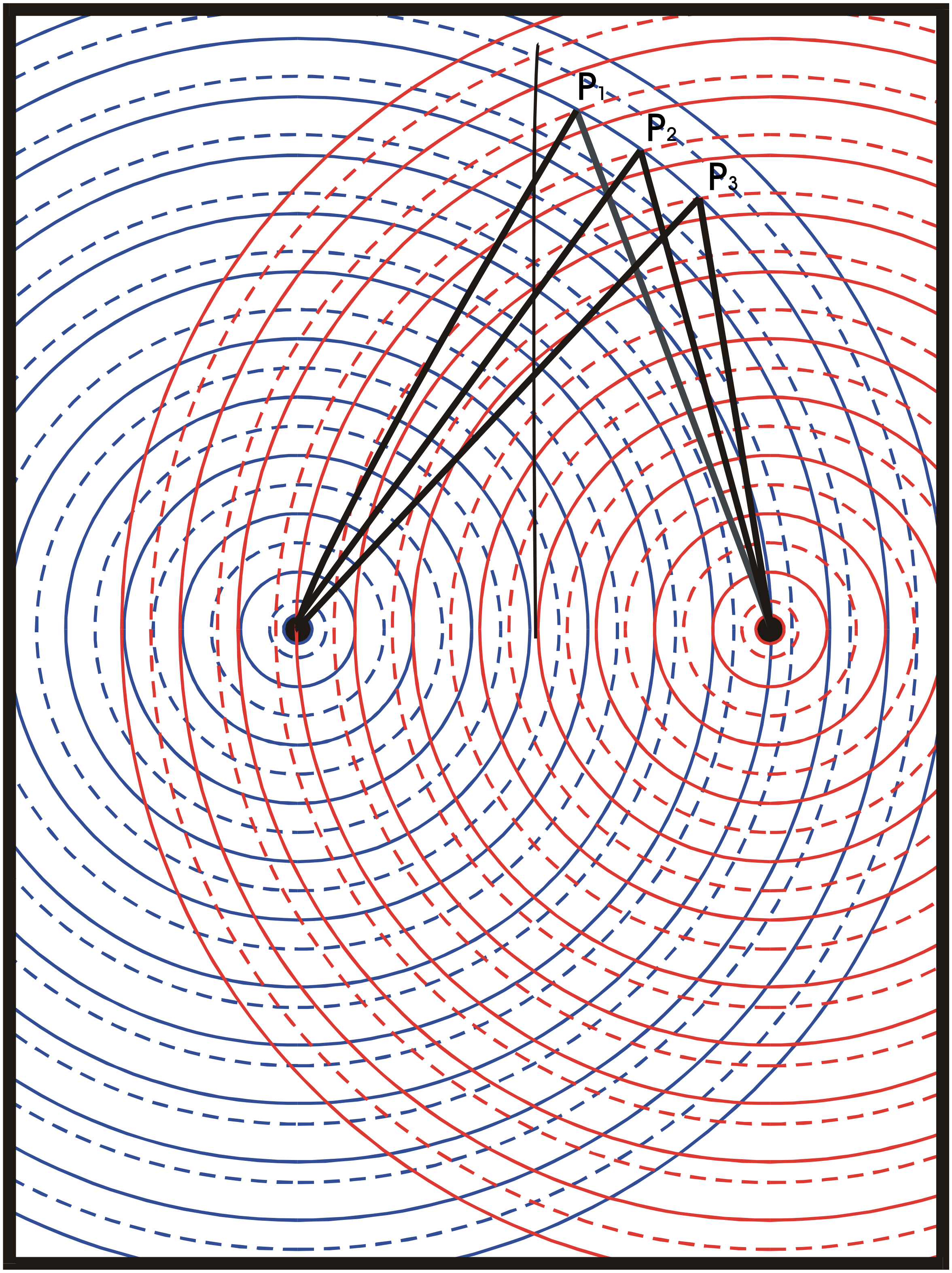
Appendix 1.6: Circular Wave Patterns




P1
P2
P3

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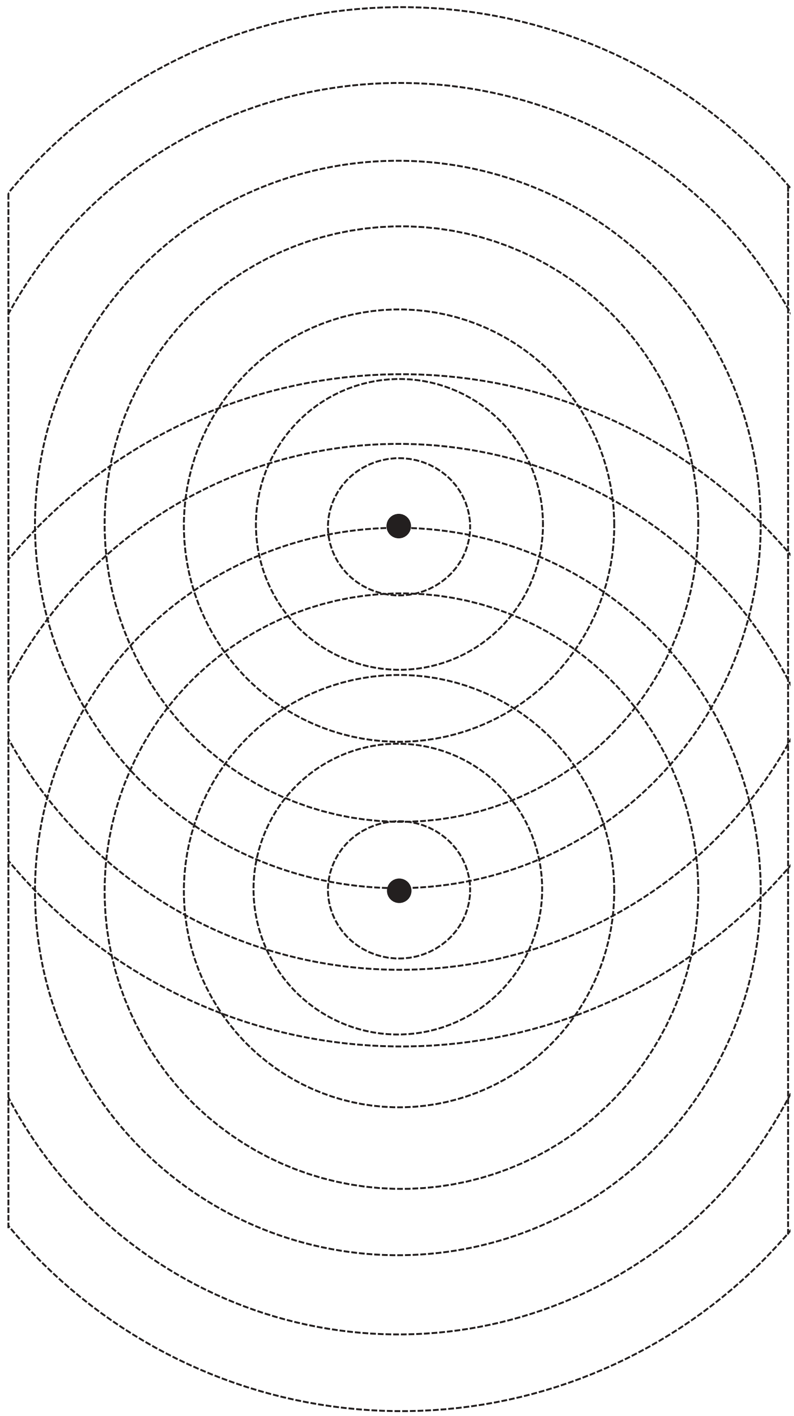
Appendix 1.7: Interference Pattern from Two Point Sources

From the diagram, represent the path difference in terms of the wavelength. That is, show $\left|\overline{P_nS_1} - \overline{P_nS_2}\right| = (n - \frac{1}{2})\lambda$, where P is a point on the nodal line and S_1 and S_2 are the sources.



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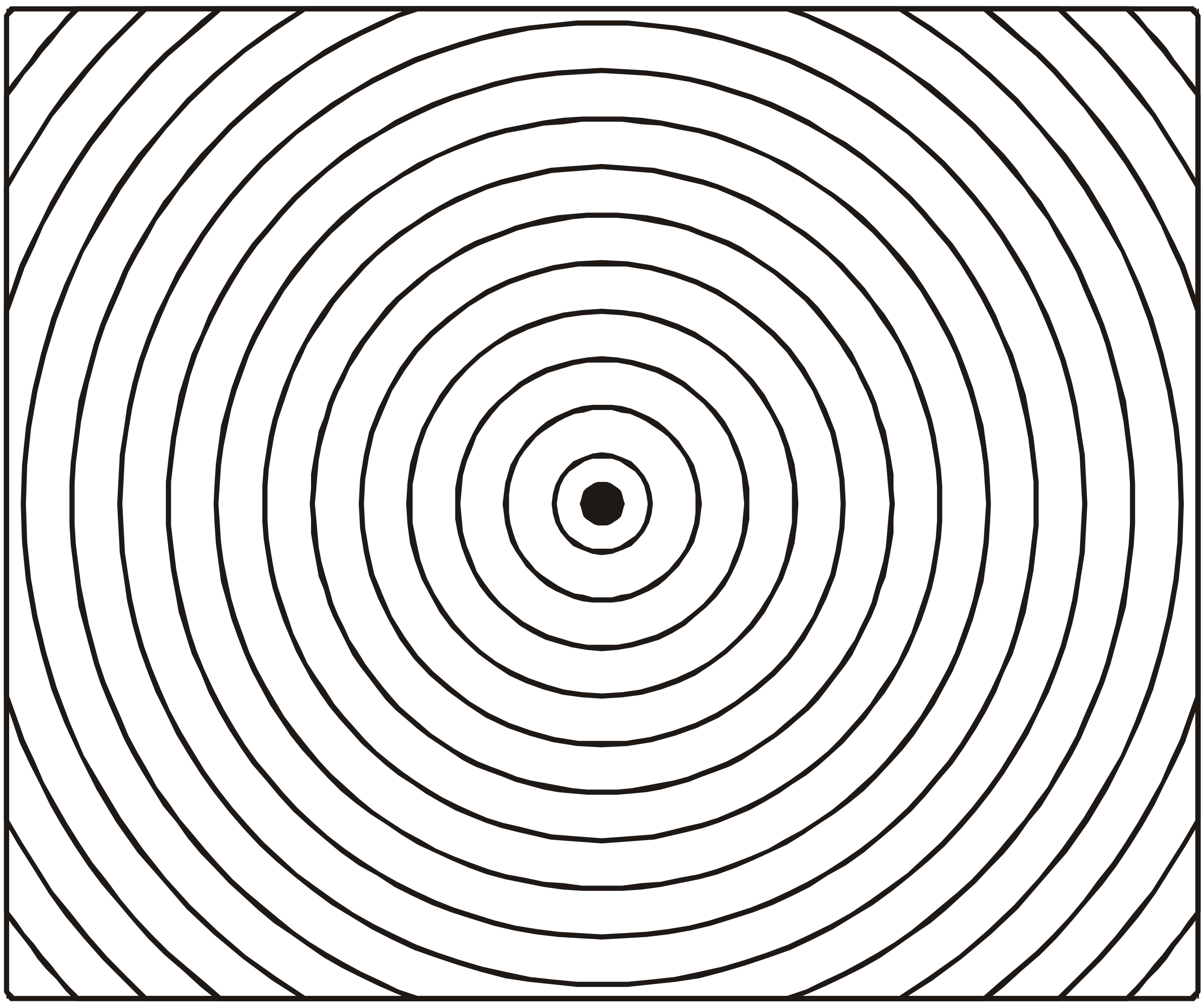
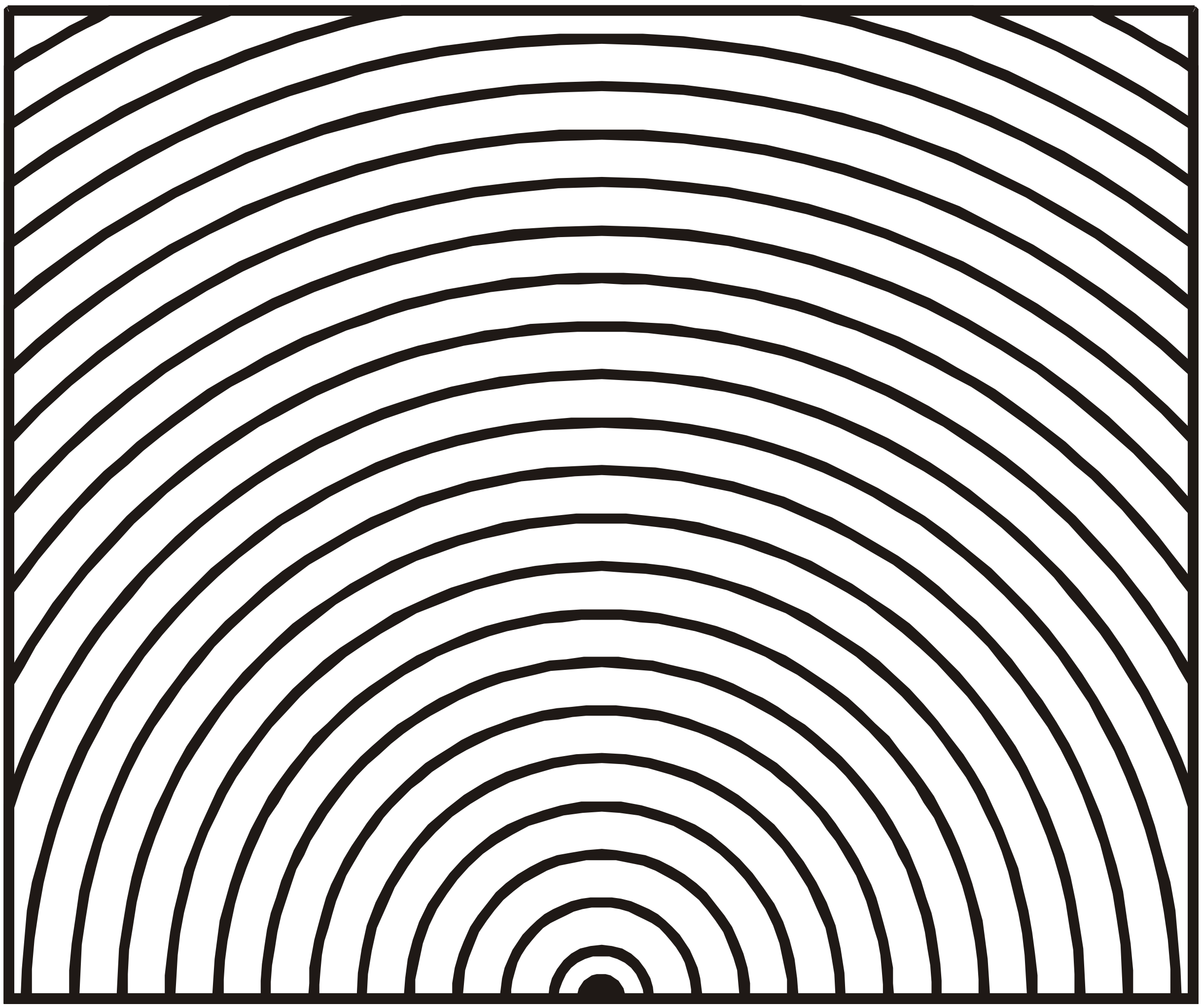
Appendix 1.8: Moiré Patterns





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Appendix 1.9: Data Table for Speed of Sound

Speed of Sound	
Material	**Speed (m/s)**
Gases at atmosphere pressure, 0°C	
Hydrogen	1270
Air	332
Oxygen	317
Carbon dioxide	258
Liquids	
Fresh water (250°C)	1493
Alcohol	1241
Solids (at 0°C)	
Aluminum	5104
Glass	5050
Steel	5050
Human bone	4040
Pine wood	3320

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Appendix 1.10: Sound Intensity Levels Table

Sound Intensity Levels (dB)	
Threshold of hearing	0
Normal breathing	10
Whisper	20
Two-person conversation	60
Vacuum cleaner	80
Air chisel	110
Rock concert	120
Jet taking off	140