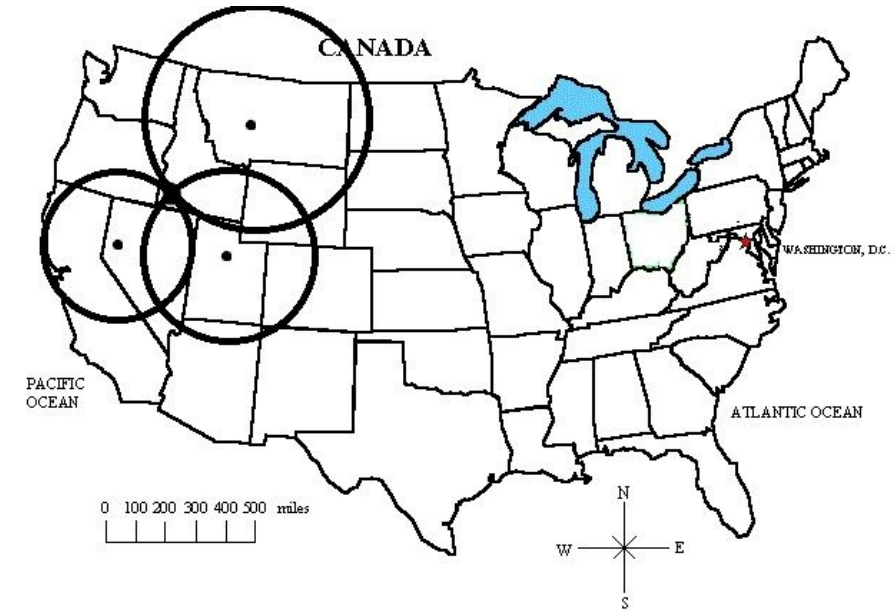
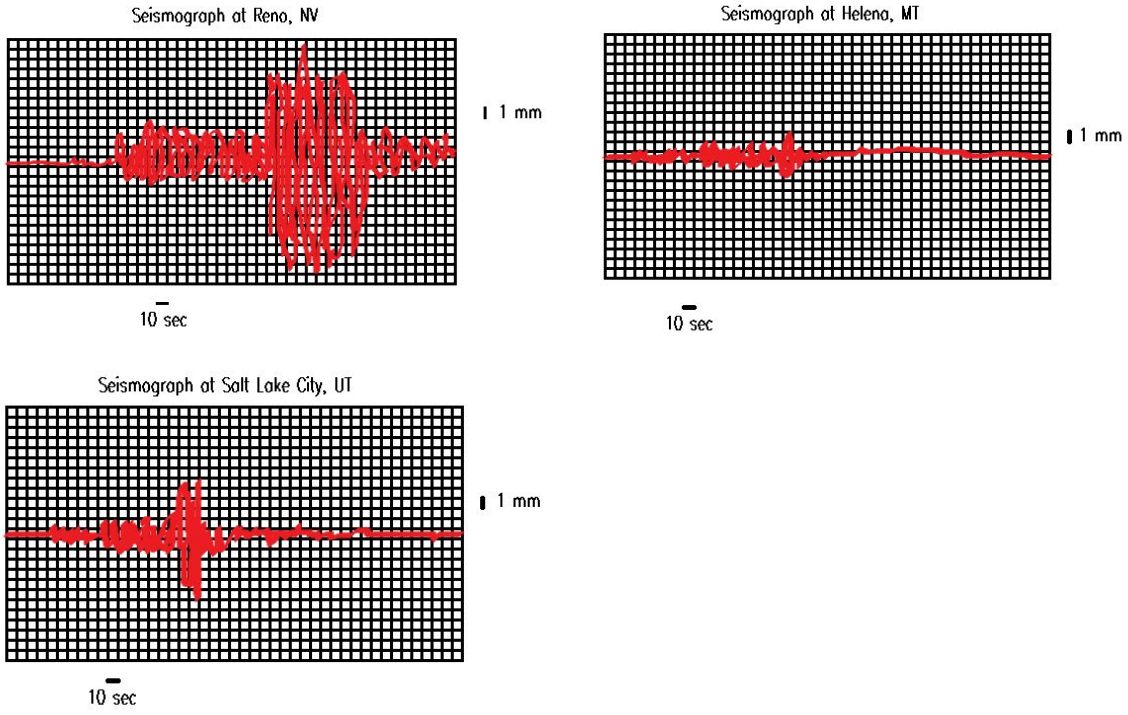
Crave the Wave Key
Station 1 (15 points)

1 (3 points for correct location, 5 more points for circles, 2 more points for calculations). 3 seismographs at Reno, NV, Salt Lake City, UT and Helena, MT detected an earthquake. Draw a dot on the epicenter of the earthquake:





2 (5 points). Find the magnitude of the earthquake.

Accept any answer from 5.1-5.4.

Station 2 (15 points)

1 (1.5 points per answer, 3 points total). You shine a magenta flashlight in a filter, and the light hits a yoga ball. The yoga ball appears cyan. Next, you repeat the same test with the filter removed. The yoga ball appears magenta. Finally, you try the test with the filter in and out with a yellow flashlight. With the filter in, the ball appears black. Without the filter, it appears red. Find the colors of the filter and the yoga ball.

Cyan filter, magenta yoga ball

2 (0.5 points per color, 3 points total). What are the primary and secondary colors of light?

Primary colors: red, green, blue

Secondary colors: yellow, cyan, magenta

3 (0.5 points per color, 3 points total). What are the primary and secondary colors of pigments?

Primary colors: yellow, cyan, magenta

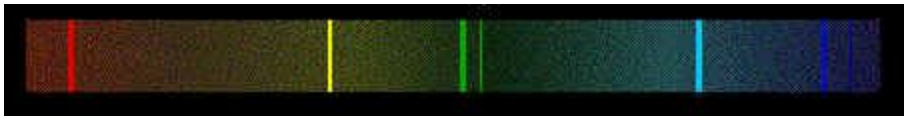
Secondary colors: red, green, blue

4 (2 points all or nothing). Pigments are **subtractive** while light is **additive**.

5 (2 points). What are optical filters?

Optical filters are devices that selectively transmit wavelengths of light.

6 (2 points all or nothing). Identify if the following are emission or absorption spectra:



Emission Spectrum

Absorption Spectrum

Station 3 (15 points)

1 (1 point). There is a recording of a truck with the sound of its horn getting higher. Is the truck approaching or leaving?

approaching

2 (1 point). What is this effect called?

The Doppler Effect

3 (3 points). A truck is moving away at 30.0 mph from a car moving towards the truck at 60.0 mph. If the truck emits a horn of frequency 500.0 Hz, what frequency in Hz does the driver of the car hear?

519 Hz

4 (3 points). What are the two types of reflection, and what is the difference between them?

They are specular and diffuse reflection. Specular reflection occurs on smooth, metallic surfaces while diffuse reflection occurs on rough surfaces.

5 (1 point per quality, 5 points total) What qualities do your image in a plane mirror possess?

1. It is **the same distance behind the mirror as I am in front of it.**
2. It is **not magnified.**
3. It is **erect.**
4. It is **left-right reversed.**
5. It is **virtual (appears to be behind the mirror).**

6 (1 point). What is the law of reflection?

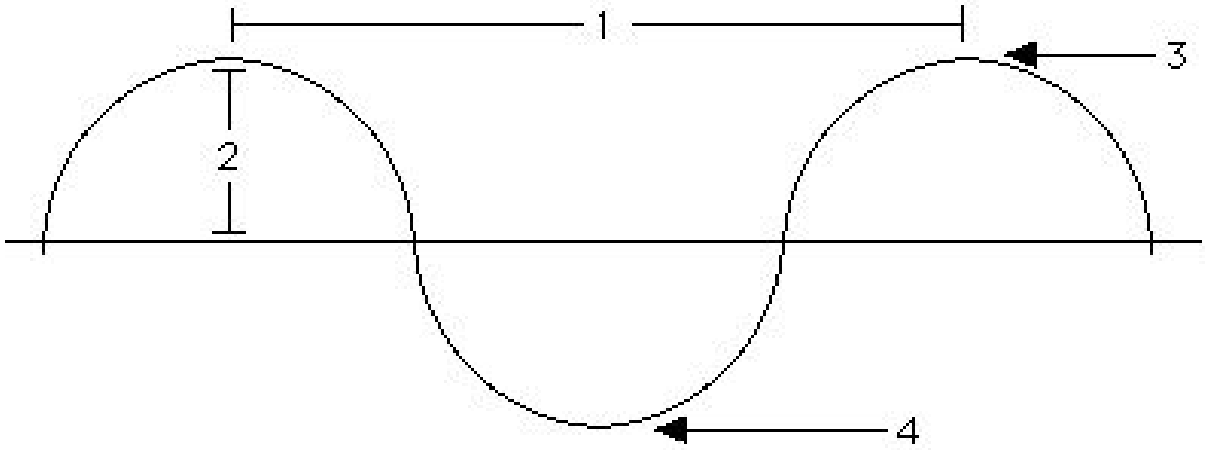
The angle of incidence equals the angle of reflection.

7 (1 point, tiebreaker). Who is credited with discovering Snell's Law?

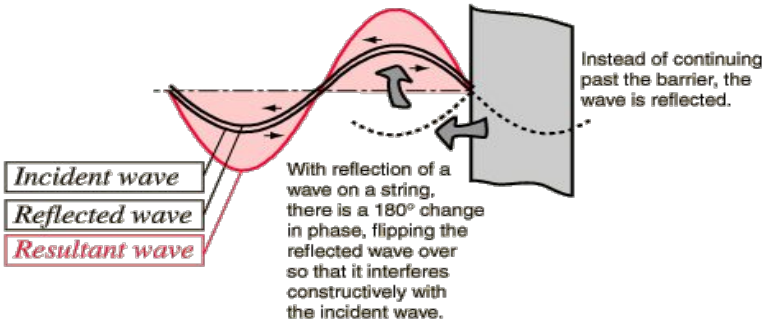
Ibn Sahl

Station 4 (15 points)

Use the following diagram for questions 1-5:



1 (0.5 point). **Wavelength**
2 (0.5 point). **Amplitude**
3 (0.5 point). **Crest**
4 (0.5 point). **Trough**
5 (1 point). What type of wave is this? **Transverse wave**
6 (2 points). Define constructive interference: **Constructive interference is the combining of two or more waves that have the same frequency and are in phase so that the resulting wave has a larger amplitude than each of the original waves.**
7 (2 points). Define destructive interference: **Destructive interference is the combining of two or more waves so that the resulting wave has a smaller amplitude than each of the original waves.**
8 (2 points for the incident and reflected waves, 1 point for the reflective surface, 3 points total). Draw a diagram of the formation of a standing wave:



9 (2 points). Where do surface waves occur?
Surface waves occur between two mediums of different densities.
10 (2 points, 1 point for mentioning the location of ground waves). What is a ground wave?

A ground wave is a radio wave close to the Earth (between the surface and the ionosphere).

Test (75 points)

1 (0.5 points for each wave in the correct position, 4 points total). Fill in the blanks for the following list of electromagnetic waves in order from lowest to highest frequency (No abbreviations!):

AM waves, FM waves, Microwaves, Infrared waves, Visible light, UV rays, X-rays, Gamma rays

2 (1.5 points). Define amplitude: **Amplitude is the maximum positive displacement of a particle from the equilibrium position.**

1 point for **Amplitude is the energy of a wave.**

3 (2 point). A light beam 30 degrees from the normal refracts from air through crown glass at an angle of **19 deg.**

4 (2.5 points). **53** deg is the angle of incidence from air through water at which a right angle is formed between the reflected beam and the refracted beam. What is this angle called?

This angle is the Brewster angle.

5 (5 points). Identical sounds of "Darius Milhaud - La création du monde" coming from a boombox, going through water and air, arrive at different times to the same place. Why is this? If the sounds arrive 0.25 seconds apart, assuming the sound never fully attenuates and has a constant speed, how far away is the source in meters and in scientific notation? Which sound comes first?

This is because sound travels faster through water than through air (The molecules are closer in water than in air). If the sounds arrive 0.25 seconds apart, the source is 1.2×10^2 meters away (accept any answer with a 0.1×10^2 meter margin of error). The sound traveling through the water will come first.

6 (1 point). What is the difference between the media of which transverse and longitudinal waves travel through?

Transverse waves can travel through vacuums while longitudinal waves cannot.

7 (2 points for reflection, 2 points for constructive interference, 4 points). How can the boundary effect amplify sound?

The boundary effect amplifies sound with boundaries reflecting waves back in phase with the original wave. This effectively doubles the amplitude because of constructive interference.

8 (3 points per velocity, 6 points total). How fast, in km/sec, do P and S-waves travel through an unknown material with a bulk modulus of 96 GPa, a shear modulus of 36 GPa and a density of 4 g/cm^3?

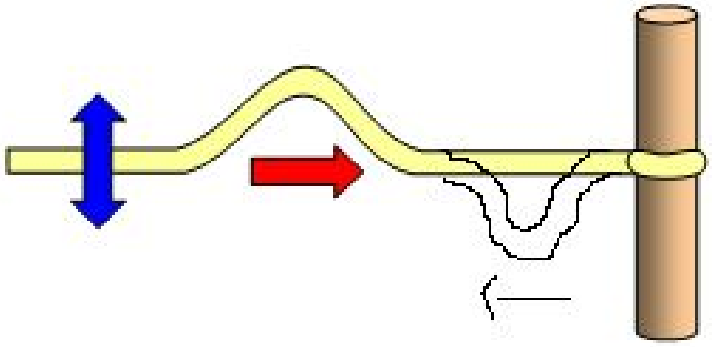
P-wave: 6 km/sec

S-wave: 3 km/sec

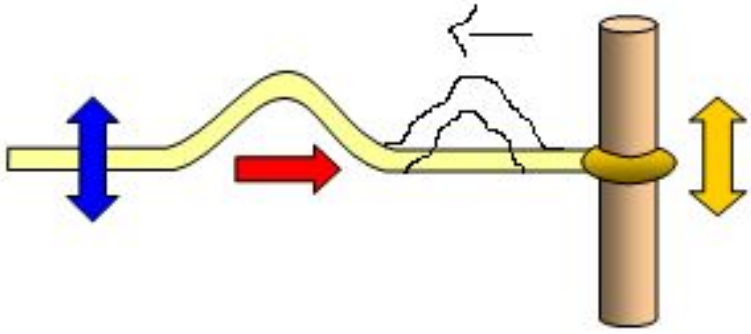
9 (2 points). **19 deg is the angle of refraction for when a light beam refracts from air into a prism of crown glass at an angle of 45 degrees.**

For questions 10 and 11, draw the reflection on the picture after the wave hits the pole.

10 (1.5 points).



11 (1.5 points).



12 (3 points). What causes the sky to be blue? Describe this phenomenon.

The blue sky is a result of rayleigh scattering. The sunlight hits molecules in the air and scatters. Rayleigh scattering scatters the blue light in sunlight more than the red light because blue light has more photon energy.

13 (2 points). You shine a laser at the moon with a frequency of 1.2 * 10^13 Hz. You then double the frequency. What is the final wavelength in meters and by what factor does the wavelength change when you double the frequency?

The final wavelength is 1.2 * 10^-5 m. The wavelength was halved.

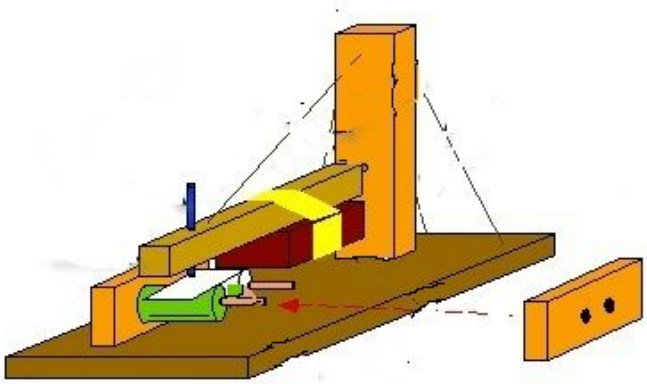
14 (2 points for correct work, 2 points for correct answer, 4 points). Name the range of photon energy, in eV to the nearest thousandth, for infrared waves. Show your work.

Frequency: $300*10^9$ Hz to $430*10^{12}$ Hz

Photon energy in Joules: E = hv

$E = (\sim 6.63*10^{-34})(300*10^9$ to $430*10^{12}) = 1.99*10^{-22}$ to $2.85*10^{-19}$

Photon energy in Electron Volts: $1.99*10^{-22}$ to $2.85*10^{-19} * 6.24*10^{18}$ = <u>0.001 to 1.778 eV</u>



15 (2 points). What type of machine is shown in the diagram above?

A seismograph

16 (2 points). What is the study of sound called?

Acoustics

17 (1 point). What are mechanical waves?

Mechanical waves are waves that require a medium to propagate.

18 (1.5 points per wave, 3 points total). What do AM and FM stand for?

Amplitude modular and Frequency modular

19 (2 points). Ripples are primarily

a. swells
b. capillary waves
c. wind waves
d. love waves

20 (1 point). Who is the hertz named after? (First and last name)

Heinrich Hertz

21 (2 points). What is the study of ocean waves (among other things) called?

Oceanography

22 (1 point). Around what wavelength in micrometers of infrared light do humans radiate?

Accept answers from 9-11 micrometers (μm)

23 (2 points). What do the Fresnel equations define?

The Fresnel equations define how much reflection and refraction (or transmission) occurs from media of different refractive indices.

24 (4 points). What are the two main types of earthquake waves? Describe the difference between them.

The two types of earthquake waves are surface waves and body waves. Surface waves propagate between the Earth and the atmosphere, i.e. the surface. Body waves propagate in the interior of the Earth.

25 (1 point per use or harm, 6 points total). What are three uses of UV rays and three harms of UV rays?

Uses: are used to kill cancer cells through ultraviolet light therapy, make Vitamin D be produced in the body, are used for UV photography, are used for disinfection and drug detection, are used to attract bugs (for bug zappers), are used in optical sensors, etc.

Harms: Can cause skin cancer, Causes sunburn, Causes skin redness, Causes eye irritation, Worsens existing skin diseases and conditions, Causes eye damage, Degrades polymers, etc.

26 (2 point). How does the Earth protect us from UV radiation?

The ozone layer protects from the UV radiation of the sun.

27 (3 points). A tsunami travels from California to Hawaii (around 2,500 miles) in 2.0 days and 2.0 hours. It takes about one minute for each wave to occur. What is the wavelength of the tsunami wave in kilometers? (Hint: 1.0 mi is approximately 1.6 km.)

1.3 kilometers

28 (2 points). You call out to your friend in another room without going to the door. If your friend hears what you say, what is this an example of?

This is an example of diffraction.

29, a, b, c, d (0.5 point for each wave, 2 points total). Identify the type(s) of waves shown.

a. 

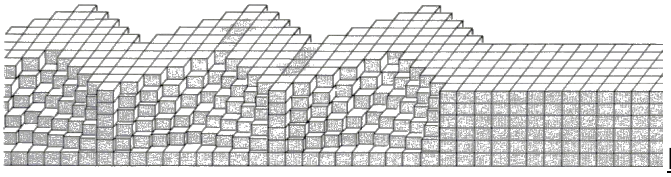
Longitudinal/Compressional Wave

b. 

Transverse/Shear Wave

c. 

Torsional Wave

d. 
Love wave (0 points for **Surface wave**)