# Physics G

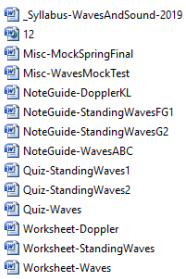
Chapters 12 and 13

Waves and Sound

| B/A | Class | Due |
|---|---|---|
| 1<br>**Apr 26/29** | **DI**-Wave Demos<br>**GW**-Waves Lab | **VF 12A, 12B, 12C** |
| 2<br>**Apr/May 30/1** | **GW**-Waves 1-15<br>**GW**-Group quiz on Waves | Turn in: Waves 1-15 |
| 3<br>**May 2/3** | **DI**-Interference Demos<br>**GW**-Interference lab | **VF 12D, 12E** |
| OP1<br>May 6/7 | **DI**-Lab Description<br>-Choose rides<br>-Plan | |
| OP2<br>May 8/9 | -Sensor Kinetics app<br>-Data Tables | |
| OP3<br>May 10 | **Oaks Park Field Trip!!** | |
| **A/B** | **Class** | **Due** |
| OP4<br>May 13/14 | **GW**-Oaks Park data analysis | |
| OP5<br>May 15/16 | **GW**-Oaks Park data analysis | |
| OP6<br>May 17/20 | **Oaks Park Presentations** | |
| 4<br>**May 21/22** | **DI**-Standing Waves demos<br>**GW**-Standing waves lab<br>**GW**-Standing Waves 1-6 (front), 1-5a-d (back) | **VF 12F, 12G** |
| 5<br>**May 23/24** | **GW**-Standing Waves quiz #1<br>**GW**-Standing Waves 7-18 | Turn in: Standing Waves quiz #1 |
| 6<br>**May 28/29** | **GW**-Standing Waves quiz #2<br>**VF**-12H, 12I | Turn in: Standing Waves quiz #2<br>Turn in: Standing Waves 1-18, 1-5a-d |
| 7<br>**May 30/31** | **DI**-Sound and standing wave demos<br>**DI**-Doppler Demos | **VF 12H, 12I** |
| **8**<br>**June 3/4** | **GW**-Doppler 1-12<br>**GW**-Mock Waves test | **VF 12K, 12L**<br>Turn in: Doppler 1-8 |
| **9**<br>**June 5/6** | **Waves Test! (farewell to seniors!)**<br>**IW**-Mock Final | |
| **10**<br>**June 7/10** | **GW**-Speed of sound lab<br>**GW**-Mock final | Turn in: Speed of sound lab |
| **Finals** | -A Meaningful Final<br>(Not too hard, not worth a ton) | |

Assignments:

- 4 Labs:
  - Waves lab /20 pts
  - Interference Lab /20 pts
  - Speed Of Sound /30 pts
  - Oaks Park Lab Presentation /100 pts
- 3 Formative assignments
  - Waves 1-15
  - Standing Waves 1-18, 1-5a-d
  - Doppler 1-8
- 1 Test:
  - Waves Test (30 points)



**Noteguide for Basic Wave Principles (Videos 12A, B, C)** **Name**_____

**Video 12A - two important principles:**

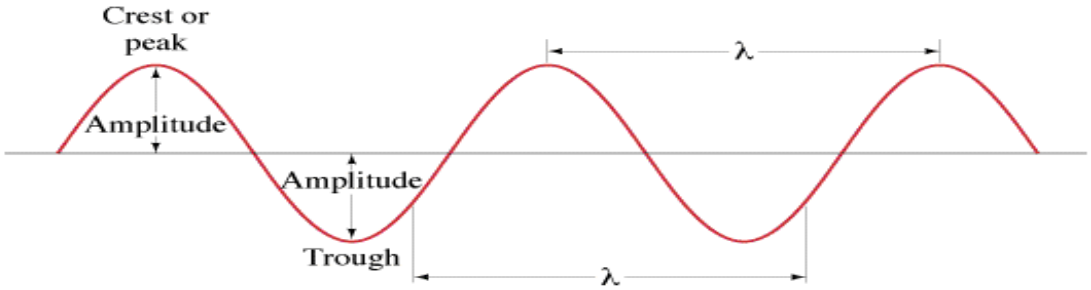
| Principle 1: | Principle 2: |
|---|---|
| | |

**Video 12B - Types of waves:**

| | **Wave moves** | **Particles move** | **Examples of** |
|---|---|---|---|
| **Transverse:** | | | |
| **Longitudinal:** | | | |

I have some demos and activities for this in class tomorrow

**Video 12C - Wave Calculations - Period, Frequency, Wavelength, and Wave speed**




| **Formula 1:** | **Formula 2:** |
|---|---|
| | |

| | Symbol | What it is | Units |
|---|---|---|---|
| Medium | | | N/A |
| Amplitude | | | Many answers |
| Wavelength | | | |
| Wave speed | | | |
| Period | | | |
| Frequency | | | |

Example 1: What is the frequency of a wave that takes 0.12 s for the whole wave to pass by?

Example 2: What is the wavelength of an A 440.0 Hz if the speed of sound is 343 m/s?

**Whiteboards:**

| | |
|---|---|
| 1. What is the period of a 60. Hz wave? | 2. What is the frequency of a wave with a period of 0.003906 s |
| 3. What is the velocity of a 1.12 m wave with a frequency of 32 Hz? | 4. What is the wavelength of a 89.1 MHz FM radio signal?<br>MHz = $10^6$ Hz<br>v = c = 3.00 x $10^8$ m/s (Speed of light) |
| 5. What is the frequency of a sound wave that has a wavelength of 45 cm, where the speed of sound is 335 m/s | 6. What is the period of a 12.0 m long radio wave?<br>v = c = 3.00 x $10^8$ m/s (Speed of light) (These are EC on the test) |

# Waves

**Frequency and Period:** $f = \frac{1}{T}$

| | |
|---|---|
| 80.0 Hz | 1. A wave passes every 0.0125 seconds. What is the frequency with which waves pass? |
| 0.00382 s | 2. Middle C is 261.6 Hz. What is its period? |
| 10. Hz | 3. What is the frequency of a wave that has a period of 0.10 seconds? |
| 0.37 Hz | 4. An earthquake wave has a period of 2.7 seconds. What is its frequency? |

**Velocity, Frequency, and Wavelength:** $v = f\lambda$

| | |
|---|---|
| 5400 m/s | 5. What is the velocity of an earthquake wave that has a frequency of 12 Hz, and a wavelength of 450 m? |
| 2540 Hz | 6. What is the frequency of a sound wave (v = 343 m/s) that is 0.135 m long? |
| 3.28 m | 7. What is the wavelength of a, $91.5 \times 10^6$ Hz (91.5 MHz) radio wave? ($v = c = 3.00 \times 10^8$ m/s) |
| 3.3 m/s | 8. What is the velocity of ocean waves if they have a wavelength of 13.2 meters, and a frequency of 0.25 Hz? |
| 2.6 Hz | 9. What is the frequency that 16 m long boxcars pass a crossing when the train is going 42 m/s? |
| 1.31 m | 10. What is the wavelength of a sound wave with a frequency of 261.6 Hz? (v = 343 m/s) |
| $7.14 \times 10^{14}$ Hz | 11. What is the frequency of a 420. nm ($420. \times 10^{-9}$ m) light wave? ($v = c = 3.00 \times 10^8$ m/s) |

**Velocity, Frequency, Period and Wavelength:** $f = \frac{1}{T}$ $v = f\lambda$ so $v = \frac{\lambda}{T}$

| | |
|---|---|
| 72.5 m/s | 12. What is the speed of a wave with a wavelength of 14.5 m, and a period of 0.20 s? |
| 0.012 s | 13. What is the period of a 4.2 m wavelength sound wave? (v = 343 m/s) |
| $3.0 \times 10^8$ m/s | 14. What is the speed of a wave with a wavelength of 150 m, and a period of 0.50μs ($0.50 \times 10^{-6}$ s)? |
| $3.33 \times 10^{-10}$ s<br>$3.0 \times 10^9$ Hz<br>(3.0 GHz) | 15. What is the period of an electromagnetic wave with a wavelength of 0.10 m? ($v = c = 3.00 \times 10^8$ m/s) What is the frequency? |

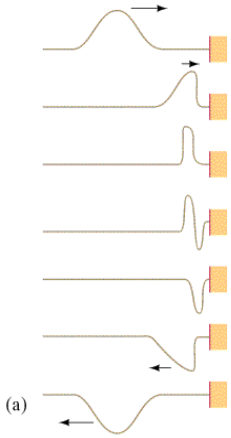
**Noteguide for Reflections (Video 12D)** **Name**_____

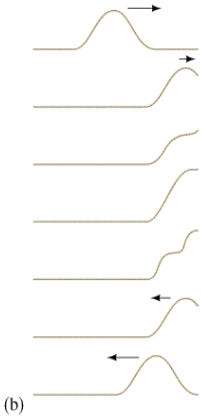
Occur when:

Examples of reflections:

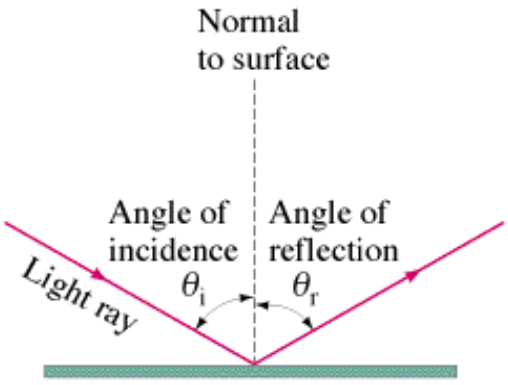
How to prevent reflections:

Fixed vs. Free ends:




Mirrors:



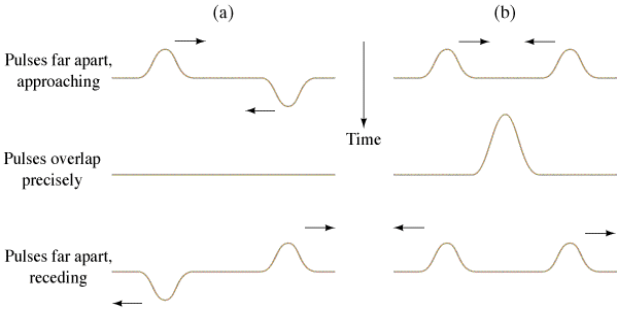

(b)

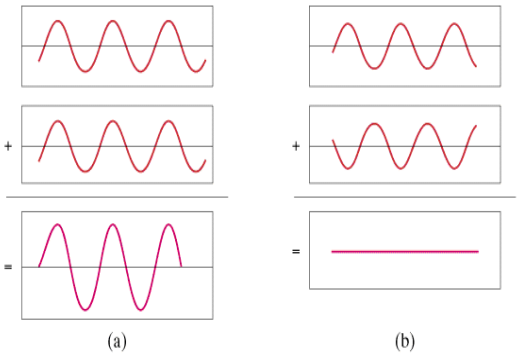
**Noteguide for Superposition and Interference (Videos 12E)** **Name**_____

**Superposition:** (Overlapping waves add)

Examples:

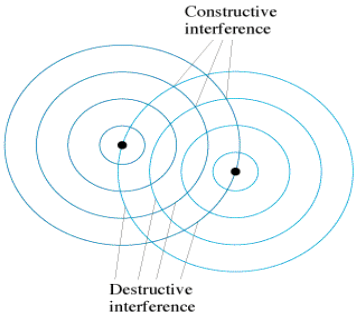
**Interference:**

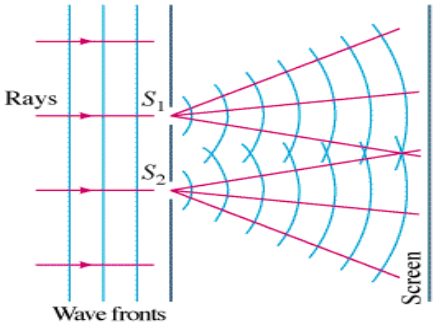



| Wavelength rule for constructive interference: | Wavelength rule for destructive interference: |
|---|---|
| | |

Other Examples:



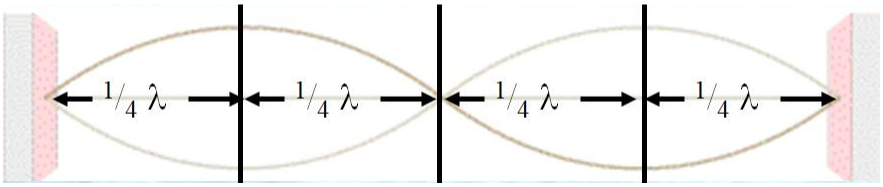
**Noteguide for Standing Waves (Videos 12F, 12G Part 1)** **Name** _____

**Video F - Intro to standing waves**
**Watch the demos of all three kinds first**
Draw the next two modes: (from the video)

| Harmonic | Both ends fixed | Both ends free | One end fixed |
|---|---|---|---|
| **1** |  |  |  |
| **2** | | | |
| **3** | | | |

Haha - we will talk in class **why** they happen. (I try to explain it on the video)

**Video G - Part 1 - Calculations**

One whole wavelength: 


So a quarter wavelength is either:

 **OR** 

**Formulas:** $L = \frac{n\lambda}{4}$

So count the quarter wavelengths:

| | |
|---|---|
|  |  |
|  |  |

**Formulas:** $L = \frac{n\lambda}{4}$ $v = f\lambda$

Example: This waveform is 8.45 m long. What is the wavelength of the standing wave? If it has a frequency of 30.4 Hz, what is the wave speed?

What is meant by the **waveform**:

What is meant by the **wavelength**:

Do **all** of the examples

This **waveform** is 45 cm long. What is the wavelength?

The **wavelength** is 0.80 m long. What is the length of the standing wave? (The waveform)

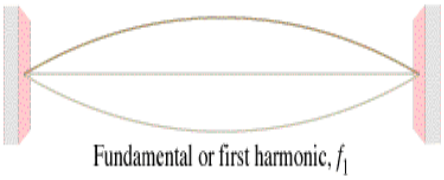
This **waveform** is 2.42 m long. What is the wavelength? If it is a sound wave (v = 343 m/s), what is the frequency?

The **wavelength** is 124 cm long. What is the length of the waveform?
If it is a sound wave (v = 343 m/s), what is its frequency

**Noteguide for Standing Waves (Videos 12G, Part 2)** **Name** _____

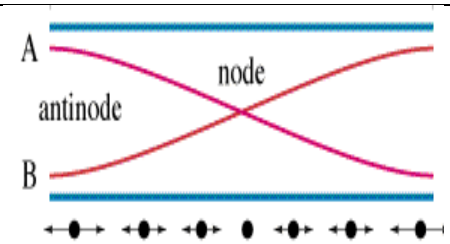
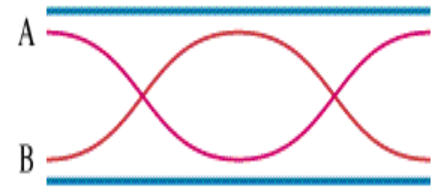
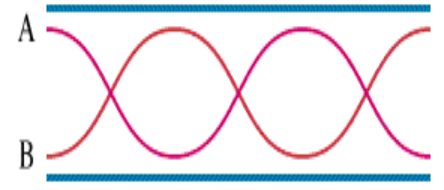
**Video G Part 2 - First three modes of vibration**

This string is 32.0 cm long, and has a wave speed of 281.6 m/s. Find the wavelength and frequency for each mode:

| | Wavelength | Frequency |
|---|---|---|
|  Fundamental or first harmonic, $f_1$ | | |
|  First overtone or second harmonic, $f_2 = 2f_1$ | | |
|  Second overtone or third harmonic, $f_3 = 3f_1$ | | |

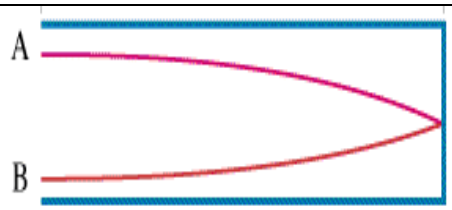
What is the pattern of frequencies:

This pipe is 1.715 m long, sound travels at 343 m/s along the pipe. Find the wavelength and frequency for each mode:

| | Wavelength | Frequency |
|---|---|---|
|   | | |
|   | | |
|   | | |

What is the pattern of frequencies:

This pipe is 1.715 m long, sound travels at 343 m/s along the pipe. Find the wavelength and frequency for each mode:

| | Wavelength | Frequency |
|---|---|---|
|  | | |
|  | | |
|  | | |

What is the pattern of frequencies:

Whiteboards:

| | |
|---|---|
| 1. The third harmonic on a flute (both ends open pipe) has a frequency of 480. Hz. How long is the waveform if the speed of sound inside the flute is 335 m/s? | 2. What is the frequency of the 2nd harmonic on a 0.31 m long pan pipe (One end open, one end closed) where the speed of sound is 343 m/s |
| 3. What is the wave speed on a 0.34m long violin string if the first harmonic has a frequency of 440 Hz? | 4. What is the frequency of the 3rd harmonic on a violin string that is 0.34 m long where the wave speed is 299.2 m/s |

**Standing Waves**

$$f = \frac{1}{T} \qquad v = f\lambda \qquad L = \frac{n\lambda}{4}$$

2.56 m

1. If this standing wave is 3.2 m long, what is the wavelength?

0.45 m
297.8 Hz

2. If this standing wave is 0.45 m long, what is the wavelength? If the wave speed is 134 m/s, what is the frequency?

0.72 m
86.4 m/s

3. If this standing wave is 0.36 m long, what is the wavelength? If the frequency is 120 Hz, what is the wave speed?

9.0 m

4. If this wavelength is 12 m long, how long is this standing wave?

0.525 m
163.3 Hz

5. If this wavelength is 2.1 m, how long is this standing wave? If the wave speed is 343 m/s, what is the frequency?

0.90 m
93.6 m/s

6. If this wavelength is 1.8 m, how long is this standing wave? If the frequency is 52 Hz, what is the wave speed?

0.34 m
1008.8 Hz
2017.6 Hz
3026.5 Hz

7. A pennywhistle is a both ends open pipe. If the standing wave in the pipe is 17 cm long, what is the wavelength and frequency of the fundamental mode of vibration, and what is the frequency of the next two modes of vibration? (Use 343 m/s as the waves speed)

0.66 m
290.4 m/s
880 Hz
1320 Hz

8. A violin has a 33 cm long string, and is tuned to A 440 Hz. (The fundamental frequency is 440 Hz, and it is a both ends fixed standing wave) What is the wavelength of the fundamental? What is the speed of waves along the string? What are the next two frequencies possible?

1.25 m
192 Hz
320 Hz

9. An organ pipe is being designed to make a fundamental tone of 64 Hz. If the speed of sound is 320 m/s inside the pipe, and the pipe is a one end open and one end closed pipe, what length should it be? What are the next two frequencies it can make?

0.423 m
0.634 m
930.7 Hz

10. A horn is a both ends open pipe. If the third harmonic has a frequency of 698 Hz, and sound has a speed of 295 m/s inside the pipe, what is the wavelength of the sound in the horn, and what is the length of the standing wave in the horn? What is the next higher frequency it can generate?

1492.3 Hz

11. A guitar has a wave speed of 485 m/s in its string, and a string length of 65 cm. What is the frequency of the fourth harmonic on this string?

0.329 m
1305 Hz

12. What length should a panpipe be (one end open, one end closed) if it is to create a fundamental tone of 261 Hz (middle C)? Use 343 m/s as the speed of sound in the pipe. What is the frequency of the third harmonic?

**Calculate the missing quantity below. L is the length of the waveform (the picture), λ is the wavelength.**

| | a | b | c | d |
|---|---|---|---|---|
| **1** |  L = 193 cm, λ = ? (386 cm) |  L = 5.76 m, λ = ? (23.0 m) |  λ = 24.0 cm, L = ? (36.0 cm) |  λ = 65.0 cm, L = ? (81.3 cm) |
| **2** |  L = 215 cm, λ = ? (215 cm) |  L = 4.32 m, λ = ? (5.76 m) |  λ = 24.0 cm, L = ? (24.0 cm) |  λ = 2.70 m, L = ? (4.05 m) |
| **3** |  L = 73.0 cm, λ = ? (58.4 cm) |  L = 3.82 m, λ = ? (2.55 m) |  λ = 93.5 cm, L = ? (187 cm) |  λ = 2.40 m, L = ? (2.40 m) |
| **4** |  L = 16.1 cm, λ = ? (9.20 cm) |  L = 3.45 m, λ = ? (1.725 m) |  λ = 183 cm, L = ? (91.5 cm) |  λ = 1.80 m, L = ? (1.35 m) |
| **5** |  L = 32.5 cm, λ = ? (14.4 cm) |  L = 5.31 m, λ = ? (2.12 m) |  λ = 63.0 cm, L = ? (158 cm) |  λ = 72.0 cm, L = ? (108 cm) |

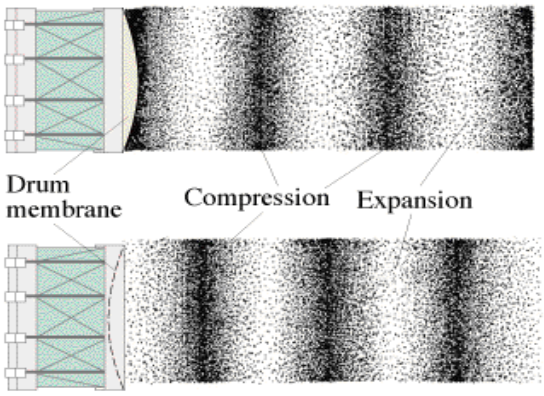
(These are just more practice problems if you are having a hard time with calculating L or λ)

More hard word problems without pictures:

13. Draw the third harmonic (The third lowest tone it can make.) of a both ends open pipe. If the speed of sound is 323 m/s, and the pipe is 57.5 cm long, what is the frequency of this harmonic? (843 Hz)
14. Draw the first harmonic (The lowest tone it can make.) of a tightly stretched string. If the string is 29.8 cm long, and the frequency of this harmonic is 322 Hz, what is the wave speed on the string? (192 m/s)
15. Draw the third possible harmonic (The third lowest tone it can make.) of a one end fixed, one end open pipe. If the pipe is 34.1 cm long, and this harmonic has a frequency of 1092 Hz, what is the speed of sound in the pipe? (298 m/s)
16. Draw the first harmonic (The lowest tone it can make.) of a both ends open pipe. If the speed of sound is 310. m/s, and the pipe is 42.1 cm long, what is the frequency of this harmonic? (368 Hz)
17. Draw the third harmonic (The third lowest tone it can make.) a guitar string. If this harmonic has a frequency of 864 Hz, and the string is 68 cm long, what is the speed of the waves in the string? (392 m/s)
18. What is the fifth harmonic (The fifth lowest tone it can make) of a 45.0 cm long panpipe? (one end fixed) if the fundamental is 180. Hz? (1620 Hz)

**Noteguide for Sound (Videos 12H)** **Name**_____

What type of wave is sound:




Range of human hearing:

Most sound is:

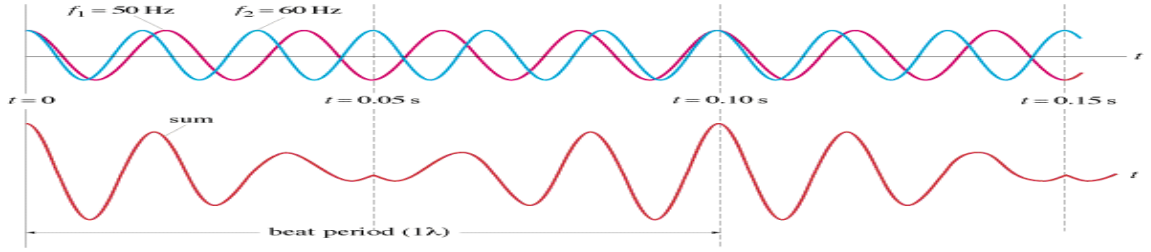
## v = (331 + 0.60T) m/s, T = temperature in $^{o}$C

Example 1 – What is the speed of sound at 20 $^{o}$C? 42 $^{o}$C?

Whiteboards:

| | |
|---|---|
| 1. What is the speed of sound in air at 80 $^{o}$C? (379 m/s) | 2. At what temperature in Celsius is the speed of sound 318 m/s? (-21.7 $^{o}$C) |

**Noteguide for Beats (Videos 12I)** **Name**_____




$$f_{beat} = |f_1 - f_2|$$

Examples:

1. I play a pitch of 256 Hz (C) on my Pennywhistle, and you play a pitch of 384 Hz (G) on your whistle. What is the beat frequency?

2. If I am playing a pitch of 384 Hz, and I hear a beat frequency of 10.0 Hz, what are the possible other frequencies that are playing?

Whiteboards:

| | |
|---|---|
| 1. What beats do you hear if you play an e 640 Hz with a c 1024 Hz?<br>(384 Hz, G in octave below the E ) | 2. If you are playing an A 440 Hz, and you hear a beat frequency of 20 Hz, what are the other possible frequencies that could be playing?<br>(460 Hz or 420 Hz ) |
| 3. The concertmaster is playing an A 440.0 Hz. Another violin hears a beat every 0.20 seconds. What frequency are they playing?<br>(445.0 Hz or 435.0 Hz ) | |

**Noteguide for Doppler (Videos 12K, 12L)** **Name** _____

**Video K - Introduction to Doppler (Watch all three videos)**

**<u>Receding</u> source/observer**

**Frequency is**_____

**<u>Approaching</u> source/observer**

**Frequency is**_____

**Video L -** Feel free to skip the derivation if it does not interest you, but write down what all the variables are in the formulas:

| **Moving Source** | **Moving Observer** |
|---|---|
| $f' = f\left(\frac{v}{v \pm u_s}\right)$<br>$f'$:<br>$f$:<br>$v$:<br>$u_s$: | $f' = f\left(\frac{v \pm u_o}{v}\right)$<br>$f'$:<br>$f$:<br>$v$:<br>$u_o$: |

**Do Examples <u>1 and 3</u>.** We will not be solving for source or observer speed, but it is extra credit on the test if you want to learn how to do it

| | |
|---|---|
| **Example 1 -** A car with a 256 Hz horn approaches you at 40.0 m/s. What frequency do you hear? (3) (use v sound = 343 m/s) | **Example 3** - You run at 8.50 m/s toward a violinist playing 660. Hz. What frequency do you hear? (Use 343 m/s as the speed of sound) |

# Doppler Effect

Use **343 m/s** as the speed of sound.

Moving Source: $f' = f\left(\frac{v}{v \pm u_s}\right)$ Moving Observer: $f' = f\left(\frac{v \pm u_o}{v}\right)$

262.2 Hz — 1. A car with a horn frequency of 240 Hz approaches you at 29 m/s. What frequency do you hear?

136.1 Hz — 2. A person hums at 150 Hz while driving away from you at 35 m/s. What frequency do you hear?

344.6 Hz — 3. Your dad is singing at 356 Hz, and you run away from him at 11 m/s. What frequency do you hear?

995.5 Hz — 4. You are riding on a train going 45 m/s. As you approach a crossing, there is a bell with a frequency of 880 Hz. What frequency do you hear?

187.3 Hz — 5. A salsa band is running away from you at 14 m/s. If you hear a pitch of 180 Hz, what frequency are they really playing?

390.6 Hz — 6. You hear a pitch of 420 Hz as a car with a man standing on the roof playing a flugelhorn approaches you at 24 m/s. What frequency is the man really creating?

442.5 Hz — 7. You are riding a rocket-propelled skateboard at 57 m/s toward a television playing a Lawrence Welk re-run. If you hear a pitch of 516 Hz, what is the real pitch the television is making?

92.7 Hz — 8. You are in a motorboat going 21 m/s away from a foghorn. You hear it at a pitch of 87 Hz, so what pitch is it really creating?

10.8 m/s away — 9. If you hear a frequency of 253 Hz as you listen to a middle C (261 Hz) being played on a piano that is on a flatbed train car, is the car going toward you or away, and how fast?

9.2 m/s toward — 10. If a car 217 Hz car horn is heard at 223 Hz, is the car approaching you or receding from you, and what is its speed?

17.5 m/s away — 11. You are riding in a train with a blindfold on, and you hear an 880 Hz crossing bell, but it appears to have a pitch of only 835 Hz. Are you moving toward or away from the bell, and how fast?

27.3 m/s toward — 12. How fast and in what direction (away or toward) do you have to run relative to a concertmaster playing an A 440 Hz so that you hear it at 475 Hz?

388.4 Hz — 13. You are driving at 27 m/s toward an oncoming driver on a highway. They are approaching you at 43 m/s. (a tad in excess of the speed limit) You honk at them with your 318 Hz horn to indicate your dissatisfaction with their driving habits. What frequency do they hear?

453.4 Hz — 14. You are driving your Porsche at 57 m/s on the Autobahn and you come behind a Prius in the left lane going only 35 m/s. You honk your 421 Hz horn at them. What frequency do they hear?

94,900.3 Hz — 15. A bat flying at 17 m/s is approaching a moth flying toward the bat at 7.0 m/s. If the bat generates an echolocation frequency of 82,500 Hz, what frequency does the bat hear reflected off the moth?

# Mock Waves Test

**1. Basic Waves**

A. What is the period of a wave with a frequency of 250 Hz? (0.0040 s)

B. What is the wavelength of a sound wave with a frequency of 440 Hz traveling at 343 m/s? (0.780 m)

C. What is the frequency of a radio wave that is 50.0 m long? ($v = c = 3.00 \times 10^8$ m/s) ($6.00 \times 10^6$ Hz or 6.00 MHz)

**2. Standing Waves:**

A. Calculate the **wavelengths** below. The length given is the length of the waveform (The picture)

L = 445 cm

(356 cm)

L = 0.64 m

(1.28 m)

L = 1.48 m

(1.48 m)

B. If this <u>wavelength</u> is 24 cm long, how long is this <u>standing wave</u>?  (18 cm)

C. A guitar has strings that are 0.65 m long, and there is a wave speed of 245 m/s along its strings. What is the frequency of the third harmonic? (The third possible mode of resonance) (565.4 Hz)

**3. Doppler (use 343 m/s as the speed of sound)**

A. You fly 185 m/s toward a stationary tuba playing a frequency of 62.0 Hz. What frequency do you hear?
(95.4 Hz)

B. An ice cream truck with a frequency of 986 Hz is driving 21.0 m/s away from you. What frequency do you hear? (929 Hz)

C. A violinist rides a Segway toward you at 14.70 m/s. You hear a frequency of 1120. Hz, what frequency are they really playing? (1072 Hz)

# Physics - Mock Spring Final!!!

## Page 1 - Kinematics and Projectile Motion

1. A car going 25 m/s goes 13.4 m. What time does it take? (0.536 s)

2. A train can accelerate at 0.150 m/s/s. What time will it take to reach its top speed of 24.0 m/s from rest? (160 s)

3. A giant lizard stops in 5.85 m in 1.15 s. What was its acceleration?(-8.85 m/s/s)

**4-6: A ball rolls off the edge of a 15.0 m tall cliff with a purely horizontal velocity, and strikes the ground at a distance of 12.4 m from the base of the cliff.**

4. What time was the ball in the air? (1.75 s)
5. What was the ball's horizontal velocity? (7.09 m/s)
6. Draw a picture of the final velocity of impact. Calculate the speed it is traveling, and find the angle below horizontal the velocity makes.
(speed = 18.6 m/s, $67.5^{o}$ below horiz.)

## Page 2 - Forces

7. If there is a net force of 42.0 N on a 3.60 kg mass, what time would it cover 37.0 m from rest? (2.52 s)

**8-9: A 1.60 kg mass hangs on a cord.**

8. What does the tension need to be in the rope to accelerate the mass upwards at 3.56 m/s/s? (+21.4 N )

9. What is the acceleration of the mass if the tension in the rope is 19.3 N? (+2.26 m/s/s)

10. A 4.25 kg block of wood has a kinetic coefficient of friction of 0.120 and a static of 0.330 between it and the level floor. If the block is sliding to the right, and I exert a force of 7.80 N to the right, what is the acceleration of the block? (+0.659 m/s/s)

## Page 3 - Work and Energy

11a. What speed must a 0.458 kg hammer go to have 60.0 J of kinetic energy? (16.2 m/s)

11b. What is the potential energy of a 2.60 kg clock weight that is 1.45 m above its lowest point? (36.9 J)

12. How much time does it take for a 450. Watt heater to produce 4580 J of heat? What heat will it put out in 32.0 s? (10.2 s, 14,400 J)

13. A sled dog has a power output of 310. W. In what time can it drag a 112 kg sled 95.0 m across a frozen lake where the coefficient of friction is 0.130? (43.8 s)

14. Mom gives 55.0 kg Tamara a push from rest on her massless sled for a distance of 7.20 m at the top of a 3.80 m tall hill. If she is going 11.0 m/s at the bottom of the hill, what force did Mom exert at the top to speed her up? (Neglect friction) (178 N)

## Page 4 - Impulse and Momentum, Circular Motion

15. A rocket engine burns 12.0 grams of fuel (0.0120 kg) in 1.10 seconds with an exhaust velocity of 782 m/s. What it the thrust of this engine? (8.53 N)

16. A bullet going 481 m/s imbeds in a stationary block of wood. The bullet and block combo are going 5.27 m/s after the collision, and the combo has a mass of 12.1 kg (Bullet and block). What was the mass of the bullet? (0.133 kg)

17. Two football players strike each other head on. Player 1 has a mass of 119 kg and is running 6.20 m/s to the East, and player 2 has a mass of 102 kg is running 4.20 m/s to the West. What is their post-collision velocity if they stick together? (Speed and direction) (1.40 m/s East)

18. How fast can your 800 Kg car go around a corner with a radius of 13 m when the available centripetal force is 6500 N? (10.3 m/s)

19. There is a force of gravity of $3.40 \times 10^{-9}$ N between a 5.00 kg mass and a wrecking ball whose centers are separated by 2.50 m. What is the mass of the wrecking ball? (63.7 kg)

20. A Rock-O-Plane has a radius of 5.64 m and a period of 6.25 s. What "g" force do they read at the top and the bottom of the ride? (0.418 "g"s, 1.582 "g"s)