RELEVANT REVIEW ASSIGNMENTS:

MOMENTUM QUIZ REVIEW

***Instructions**: Show your work completely in your journal when answering the following questions.*

1. If a 3.0 kg object moves 10. meters in 2.0 seconds, what is its average momentum?

2. An impulse of 30.0 N·s is applied to a 5.00 kg mass. If the mass had a speed of 100. $^{m}/_{s}$ before the impulse, what would its speed be after the impulse?

3. A 15 N force acts on an object in a direction due east for 3.0 seconds. What will be the change in momentum of the object?

4. A 1.0 kg mass changes speed from 2.0 $^{m}/_{s}$ to 5.0 $^{m}/_{s}$. What is the change in the object's momentum?

5. A net force of 12 Newtons acting North on an object for 4.0 seconds will produce an impulse of what?

6. A ping-pong gun originally at rest fires a ball. What is the sum of the gun's and ball's momenta after the shot?

7. A moving freight car runs into an identical car at rest on the track. The cars couple together. Compared to the velocity of the first car before the collision, what is the velocity of the combined cars after the collision?

8. If a 54 N·s impulse is given to a 6.0 kg object, what is the object's change in momentum?

9. Which quantities do not always occur in equal and opposite pairs when and interaction takes place within a system?
   a. Impulses
   b. Accelerations
   c. Forces
   d. Momenta changes

10. Object A has a momentum of 60.0 N·s. Object B, which has the same mass, is standing motionless. Object A strikes object B and stops. If the mass of object B is 6.0 kg, what is the velocity of object B after the collision?

MOMENTUM AND ENERGY QUIZ REVIEW

Instructions: *Show your work completely in your journal when answering the following questions.*

1. Define the following (conceptual definition and equation):
   a. Momentum
   b. Impulse
   c. Conservation of Momentum
   d. Kinetic Energy
   e. Potential Energy
   f. Mechanical Energy
   g. Conservation of Energy
   h. Elastic Collision
   i. Inelastic Collision

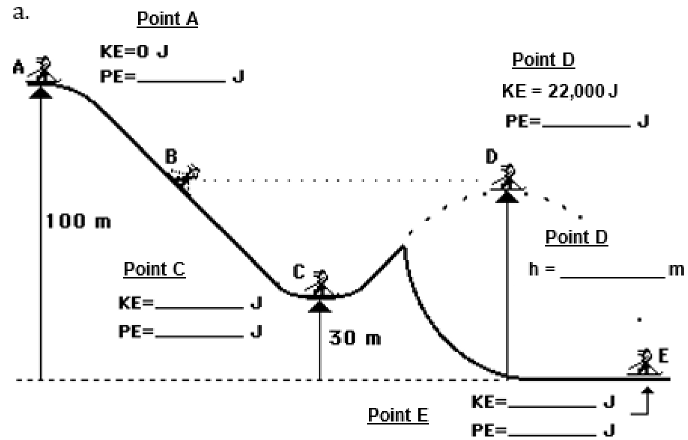
2. What is the kinetic energy for the following objects?
   a. A 65 kg runner moving with a speed of 7.0 $^{m}/_{s}$
   b. A 2.0 million kg space shuttle with a launch speed of 44 $^{m}/_{s}$
   c. A 5.0 kg bowling ball moving with a speed of 9.5 $^{m}/_{s}$
   d. A 75 kg skier at rest

3. What is the potential energy for the following objects?
   a. A 0.50 kg orange sitting on a shelf 2.0 meters off the ground
   b. A 68 kg snowboarder sitting on a ramp 15 meters high
   c. A 1200 kg car parked in a garage 6 stories up (21 meters)
   d. A 16 kg box sitting on the floor

4. You decide to apply your vast knowledge of physics to baseball. You swing the bat and, oops, it's a pop up. The .145 kg ball starts straight up off the bat at 35 m/s.
   a. How much kinetic energy does the ball have initially? At the top?
   b. At the top, what is the ball's potential energy?
   c. The catcher catches the ball. Just before it hits, what is the ball's kinetic energy? Potential energy?

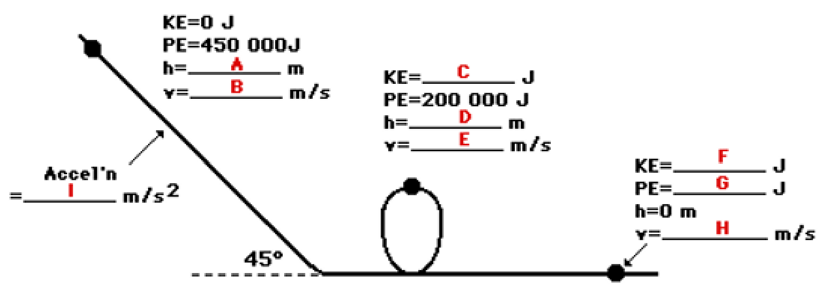
5. You go next door from the baseball field and find the local pool. You climb up onto the 10 m platform to take a dive. If your mass is 50 kg:
   a. What is the change in potential energy when you climb up there?
   b. You jump. How fast are you going just before striking the water 10 m below?

6. A world-class Olympic athlete starts from rest on top of a 100-meter hill, skis down the incline and makes a world-record setting jump. If she has a mass of 55 kg, use the information given in the diagram to fill in the missing information.
   a.



   b. Calculate her velocity at points B and C

7. Use the law of conservation of energy to fill in the blanks at the various marked positions for a 1000 kg roller coaster car.

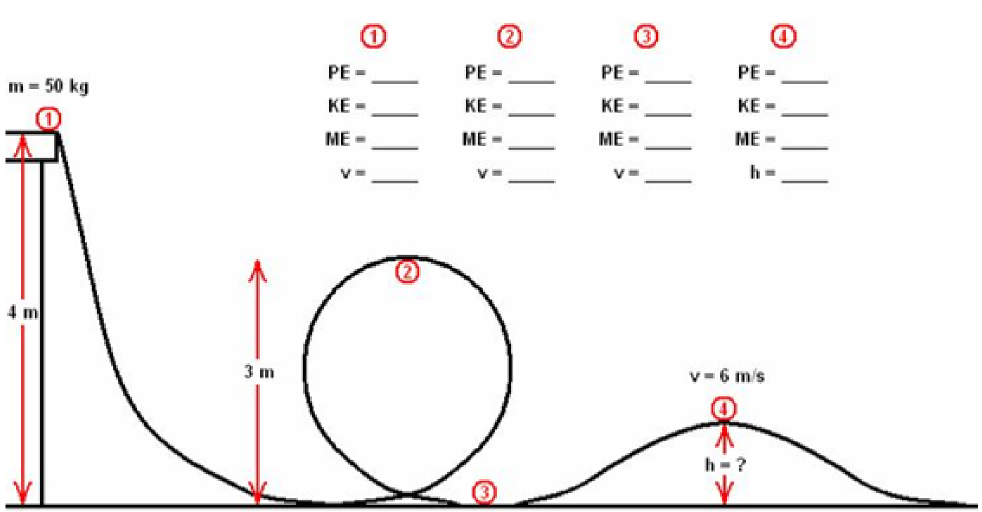


Tying It All Together: Refresher For Unit 5

***Instructions:** Show all of your work completely in your journal, including the equations used in variable form. Pay attention to sig figs and units; use complete sentences if applicable.*

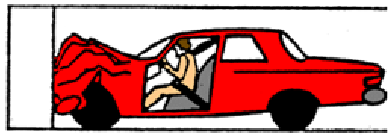
1. Rick and Carl come across an abandoned bowling alley. Rick has an 8.0 kg ball and rolls it at 2.0 $^{m}/_{s}$ toward a 12 kg bowling ball at rest. If the 12 kg ball has a final velocity of 1.5 $^{m}/_{s}$, calculate the velocity of the 8.0 kg ball. What type of collision is this?

2. Use conservation of energy to fill in the blanks for the diagram below. Show all of your work!



3. Daryl finds an old ballistics lab and decides to have some fun with physics. The muzzle velocity of guns (the velocity of the bullet right as it leaves the gun) can be found by firing the bullet into a massive block of wood on a frictionless surface and measuring the final velocity of the block.
   a. What type of collision is this?
   b. Given that the mass of the bullet is 13 grams, the mass of the block is 4.0 kg and the final velocity of the block with the embedded bullet is 1.2 $^{m}/_{s}$, find the initial velocity of the bullet.
   c. What is the magnitude of change in momentum experienced by the bullet just after impact?
   d. If the bullet slows to a stop in 0.090 seconds, what is the magnitude of average **force** on the bullet?
   e. Describe how momentum and energy are conserved in this situation?

4. A 1200 kg car is crash-tested against a rigid wall. The car is accelerated by a cable underneath it, which provides a constant force of 500. N for a distance of 15.0 m.
   a. What is the velocity just before it hits the wall?
   b. The car's "crumple zone" crumples 2.30 m upon impact. What is the force the car experiences upon impact?



4. Glenn remembers when he was in spring training! His favorite memory is about his first homerun! The ball was pitched at 45 $^{m}/_{s}$ and he swung his bat with an initial speed of 31 $^{m}/_{s}$. After the bat and the ball collided, the ball left the bat at homerun velocity, 67 $^{m}/_{s}$. The time of contact was 0.0015 sec. The mass of the bat was 1.0 kg and the mass of the ball was 0.14 kg.
   a. What was the change in momentum of the baseball?
   b. What was the force of impact of the bat against the ball?
   c. By how much was the bat slowed down by the impact?

5. Maggie is looking to play a trick on Beth by dropping a water balloon on her head. Her plan is to climb a tree, sit on a branch and drop the water balloon as Beth walks underneath. Sounds good, huh? ☺
   a. If she carries this 0.75 kg balloon up a tree 15 m vertically, how much work has she done to the balloon?
   b. When Maggie drops the balloon on Beth's head (approximately 2.0 m above the ground), how fast will the balloon be traveling? *(Hint: Use energy equations!)*
   c. If Beth thinks quick, dodges and catches the balloon with a downward motion of her hands, such that she exerts a constant force on the balloon for 0.30 seconds, what is the magnitude of this force? *(Hint: think impulse!)*
   d. Why would the balloon break if it hit Beth's head, but probably not if she caught it with a downward motion? Use appropriate physics terminology in your answer.

Unit 5 Test Review

Instructions: *Show all of your work completely in your journal, including the equations used in variable form. Pay attention to sig figs and units; use complete sentences if applicable.*

1. In your own words, define the following terms. Include the conceptual definition, equation(s) and unit(s):
   a. Momentum
   b. Impulse
   c. Conservation of Momentum
   d. Kinetic Energy
   e. Potential Energy
   f. Mechanical Energy
   g. Conservation of Energy
   h. Work
   i. Work-Energy Theorem
   j. Power

2. Compare and contrast elastic and inelastic collisions. Make sure that you discuss what quantities are conserved in these types of collisions!

3. What are the relationships between the following quantities (i.e. – inverse, directly proportional, etc.)?
   a. Momentum and Velocity
   b. Impulse and Time
   c. Force and Time
   d. Impulse and Δ Momentum
   e. Kinetic and Potential Energy
   f. Kinetic Energy and Velocity
   g. Potential Energy and Height
   h. Work and Force
   i. Work and Δ Kinetic Energy
   j. Power and Work
   k. Power and Time

4. If you fire a bullet from a pistol and a revolver with a longer barrel, which will have greater velocity when it leaves the barrel? Why?

5. You are having a water balloon fight with your friends. Why are your water balloons more likely to break if you hit a friend who is not prepared versus letting them catch it?

6. Which is more damaging: running into a solid wall or colliding head on (with the same speed from the wall) with an identical car moving at the same speed? Why?

7. Two skiers are moving toward each other and collide. If the come to rest at the point of impact, what do we know about their motion before the collision?

8. When we talk about work, we are looking at a force causing motion. What forces are doing work in the following situations?
   a. A box is pushed 5 meters across the floor
   b. A sky-diver falls 100 meters towards the Earth
   c. An elevator is lifted 20 meters upward

9. Why is it important for work to depend on displacement versus distance? What do we know about work as a result?

10. Two boats of unequal mass travel across the bay at the same speed and in the same direction. If the water exerts the same frictional force on the boats, how will their stopping distances compare?

11. Basketball A and B each have a mass of 3.0 kg and are moving at 4.0 $^{m}/_{s}$.
    a. What is Basketball A's momentum? Basketball B?
    b. If A and B are moving in the same direction, what is the momentum of the system? What if they move in opposite directions?

12. A roller coaster cart starts at the bottom of a hill with some speed. At some point while moving up the hill, the cart has a potential energy of 80.0 J and a kinetic energy of 20.0 J.
    a. When the cart is at the top of a hill and at rest, what is its potential energy?
    b. What was the initial speed of the cart at the bottom of the hill if the cart has a mass of 85.0 kg?

13. An ice skater is at rest on the ice when she catches a prop that her partner threw to her. If the skater has a mass of 55 kg, the prop is 7.0 kg, and it was initially moving towards her at 18 $^{m}/_{s}$, how fast will the skater with the prop be moving after she catches the prop?

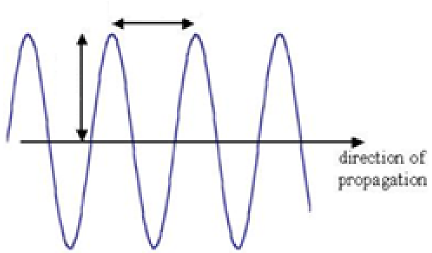
14. What is the work done by a 35 N force exerted at an angle of 25° to push a box of tools 15 meters?

15. What is the power supplied by a constant 75 N force if the object has an average speed of 12 $^{m}/_{s}$?

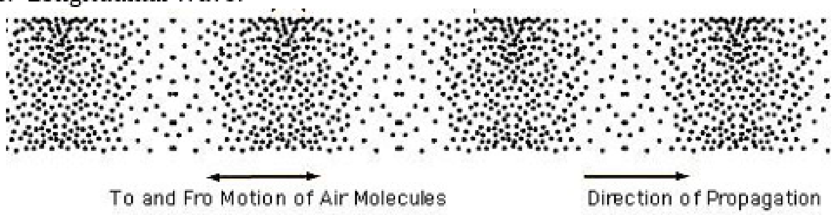
WAVES, WAVE BEHAVIOR, GEOPHYSICS AND SOUND REVIEW

***Instructions**: Show all of your work completely in your journal, including the equations used in variable form. Pay attention to sig figs and units; use complete sentences if applicable.*

1. Define and provided examples for the following types of waves:
   a. Transverse
   b. Longitudinal
   c. Surface
2. What is the only factor that affects the speed of a mechanical wave?
3. Define and list the variables for the following terms:
   a. Frequency
   b. Period
   c. Wave Speed
   d. Amplitude
   e. Wavelength
   f. Sound Intensity
4. Sketch and label the following diagrams:
   a. Transverse Wave:



   b. Longitudinal Wave:



5. Define and sketch a diagram for each of the following wave behaviors:
   a. Constructive Interference
   b. Destructive Interference
   c. Reflection
   d. Fixed vs. Free Reflection
   e. Refraction
   f. Diffraction
6. What is the superposition principle? What does it mean for mechanical waves?
7. Define the following:
   a. Primary Waves
   b. Secondary Waves
   c. Epicenter
   d. Focus
   e. Earthquake
   f. Tsunami
8. What are the events that can cause earthquakes? Tsunamis?
9. What are the 3 types of plate boundaries we learned about? How do plates move relative to each other with these types of boundaries?
10. How do seismographs work?
11. What's the difference between a water wave and a tsunami?
12. Why do the amplitudes of tsunamis increase as they approach the shore?
13. Define pitch; what wave property is it most closely related to?
14. Define loudness; what wave property is it most closely related to?
15. If frequency changes, what other wave properties are changed? Are they directly or indirectly related?
16. How does air temperature affect the speed of sound? List an equation to support your reasoning.
17. Explain how the following parts of your ear are related to your ability to hear:
    a. Eardrum
    b. Hammer
    c. Anvil
    d. Stirrup
    e. Cochlea
18. Define the following terms:
    a. Infrasonic frequencies
    b. Ultrasonic frequencies
    c. Subsonic speeds
    d. Supersonic speeds
19. Define the Doppler Effect. How does the apparent frequency shift for an observer based on the motion of the source?
20. A tuning fork with a frequency of 480 Hz is played in a room with a temperature of 25°C.
    a. What is the period of the sound wave?
    b. What is the velocity of the sound wave produced?
    c. What is the wavelength of the resulting sound wave?
21. The velocity of the primary waves produced by an earthquake is 8900 $^{m}/_{s}$ and that of the secondary waves is 5100 $^{m}/_{s}$. A seismograph records the arrival of the transverse waves 74 s after the arrival of the longitudinal waves. How far away is the earthquake?

Unit 6/Semester 2 Final Review

Instructions*: Show all of your work completely in your journal, including the equations used in variable form. Pay attention to sig figs and units; use complete sentences if applicable.*

1. Define the Doppler Effect. How does the apparent frequency for sound waves shift for an observer based on the motion of the source? How does this differ from the Doppler Effect for light waves?

2. Define and each of the following wave behaviors and provide examples from mechanical waves, sound waves, and EM waves (such as light):
   a. Interference
   b. Transmission
   c. Absorption
   d. Reflection
   e. Refraction
   f. Diffraction

3. What is a beat frequency? Why is the pattern of beats produced?
   a. A tuning fork has a frequency of 465 Hz. When a second tuning fork is struck, beat interference patterns occur with a beat frequency of 5 Hz. What is the lowest and highest frequency of the second fork?

4. What is a standing wave and how is it created? What are nodes and anti-nodes?
   a. Sketch standing waves in a string for the first 4 harmonics. What general equation can be applied to standing waves in a string?

5. Sketch standing waves in an open-end resonator for the first 4 harmonics. What general equation do we use for standing waves in an open pipe?
   a. A flute acts as an open-end resonator. If the flute has a resonant length of 25 cm, what is the wavelength of the 3^{rd} harmonic frequency?

6. Sketch standing waves in a closed-end resonator for the first 4 harmonics. What general equation do we use for standing waves in a closed pipe?
   a. An organ pipe acts as a closed-end resonator. What is the length of an organ pipe which has a fundamental frequency of 18 Hz?

7. What is an EM Wave? What is the Electromagnetic Spectrum? How is it laid out in terms of frequency, wavelength, and energy?

8. List applications of the following types of EM waves:
   a. Gamma Rays
   b. X-Rays
   c. Ultraviolet Rays
   d. Visible Light
   e. Infrared Radiation
   f. Microwaves
   g. Radio Waves

9. What is the speed of light? If it is constant, why does it sometimes seem to change with the medium?

10. Explain Snell's Law and index of refraction.
    a. List the equations for each and explain each of the variables.
    b. A beam of light passes from water into glass. The index of refraction for water (n_{water}) is 1.33 and the angle of incidence is 25°. If the angle of refraction is 22°, what is the index of refraction for glass?

11. Define total internal reflection.
    a. What is the critical angle and how does it relate to total internal reflection?
    b. What are some applications of total internal reflection?

12. What is the range of the visible spectrum from shortest to longest wavelength?
    a. What colors do we typically say make up the visible spectrum?
    b. Is white a color of light? Why or why not?
    c. Why are sunsets red? Why is the sky blue?
    d. What is the relationship between energy and frequency for a photon?

13. How can we use prisms to prove white light is made up of all the visible colors of light? What is dispersion?

14. Draw and label a diagram for both additive and subtractive color mixing.
    a. What are examples of additive color mixing? Subtractive color mixing?
    b. What are the primary, secondary, and complementary colors of light?
    c. What are the primary and secondary colors of ink/pigment?
    d. Is black a color of light? Why or why not?
    e. If you shine a red flashlight and a blue flashlight at a white wall, what color will you see where the flashlight beams overlap?
    f. What color is a yellow ball when viewed under cyan light?

15. You decide to kick off your summer with a relaxing cruise around Lake Sammamish in your friend's boat. But a storm rolls in to ruin your fun!
    a. If the temperature drops to 15.0°C, what is the speed of sound in air on the lake?
    b. You see a big flash of lightening and count 2.60 seconds before hearing the thunder. How far away is the storm?
    c. How far did the flash of lightening travel in the 2.60 seconds it took for the sound wave from the thunder to reach you?
    d. If the rumble of the thunder had an average frequency of 95 Hz, what was the wavelength of the sound wave?
    e. What is the period of the thunder's sound wave?

RELEVANT REVIEW ANSWER KEYS:

MOMENTUM QUIZ REVIEW KEY

Instructions*: Show your work completely in your journal when answering the following questions.*

1. If a 3.0 kg object moves 10. meters in 2.0 seconds, what is its average momentum?

$$\bar{v} = \frac{d}{t} = \frac{10\ \text{m}}{2.0\ \text{s}} = 5.0\ {}^{\text{m}}/_{\text{s}}$$

$$p = mv = (3.0\ \text{kg})(5.0\ {}^{\text{m}}/_{\text{s}})$$

$$\boxed{\boldsymbol{p = 15\ \text{N} \cdot \text{s}}}$$

2. An impulse of 30.0 N·s is applied to a 5.00 kg mass. If the mass had a speed of 100. ${}^{\text{m}}/_{\text{s}}$ before the impulse, what would its speed be after the impulse?

$$I = m \cdot \Delta v = m(v_2 - v_1) \rightsquigarrow v_2 = \frac{I}{m} + v_1 = \frac{30.0\ \text{N} \cdot \text{s}}{5.00\ \text{kg}} + 100\ {}^{\text{m}}/_{\text{s}}$$

$$\boxed{\boldsymbol{v_2 = 106\ {}^{\text{m}}/_{\text{s}}}}$$

3. A 15 N force acts on an object in a direction due east for 3.0 seconds. What will be the change in momentum of the object?

$$I = F \cdot \Delta t = (15\ \text{N})(3.0\ \text{s})$$

$$\boxed{\boldsymbol{I = \Delta p = 45\ \text{N} \cdot \text{s}}}$$

4. A 1.0 kg mass changes speed from 2.0 ${}^{\text{m}}/_{\text{s}}$ to 5.0 ${}^{\text{m}}/_{\text{s}}$. What is the change in the object's momentum?

$$\Delta p = m \cdot \Delta v = m(v_2 - v_1) = (1.0\ \text{kg})(5.0\ {}^{\text{m}}/_{\text{s}} - 2.0\ {}^{\text{m}}/_{\text{s}})$$

$$\boxed{\boldsymbol{\Delta p = 3.0\ \text{N} \cdot \text{s}}}$$

5. A net force of 12 Newtons acting North on an object for 4.0 seconds will produce an impulse of what?

$$I = F \cdot \Delta t = (12\ \text{N})(4.0\ \text{s})$$

$$\boxed{\boldsymbol{I = 48\ \text{N} \cdot \text{s}}}$$

6. A ping-pong gun originally at rest fires a ball. What is the sum of the gun's and ball's momenta after the shot?

$$\boxed{\boldsymbol{p_{before} = p'_{after} = 0\ \text{N} \cdot \text{s}}}$$

7. A moving freight car runs into an identical car at rest on the track. The cars couple together. Compared to the velocity of the first car before the collision, what is the velocity of the combined cars after the collision?

$$p_{before} = p'_{after}$$

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2)\, v' \rightsquigarrow m v_1 + 0 = (2m) v' \rightsquigarrow \boxed{\boldsymbol{v' = \frac{1}{2} v_1}}$$

8. If a 54 N·s impulse is given to a 6.0 kg object, what is the object's change in momentum?

$$\boxed{\boldsymbol{I = \Delta p = 54\ \mathrm{N \cdot s}}}$$

9. Which quantities do not always occur in equal and opposite pairs when and interaction takes place within a system?
   a. Impulses **TRUE**
   b. ~~Accelerations~~ **FALSE**
   c. Forces **TRUE**
   d. Momenta changes **TRUE**

10. Object A has a momentum of 60.0 N·s. Object B, which has the same mass, is standing motionless. Object A strikes object B and stops. If the mass of object B is 6.0 kg, what is the velocity of object B after the collision?

$$p_{before} = p'_{after}$$

$$m_1 v_1 + m_2 v_2 = m_1 v'_1 + m_2 v'_2 \rightsquigarrow 60\ \mathrm{N \cdot s} + 0 = 0 + (6.0\ \mathrm{kg}) v'_2$$

$$\boxed{\boldsymbol{v'_2 = 10.\ ^{\mathrm{m}}/_{\mathrm{s}}}}$$

MOMENTUM AND ENERGY QUIZ REVIEW KEY

***Instructions**: Show your work completely in your journal when answering the following questions.*

1. Define the following (conceptual definition and equation):
   a. Momentum

      Momentum is similar to inertia in motion; $\boldsymbol{p = m \cdot v}$

   b. Impulse

      Impulse is a force applied over a time interval; $\boldsymbol{I = F\Delta t = \Delta p}$

   c. Conservation of Momentum

      The momentum of a system before an event is equal to momentum afterward.

      $$\boldsymbol{p_{before} = p'_{after}}$$

   d. Kinetic Energy

      Energy due to motion; $\boldsymbol{E_K = \frac{1}{2}mv^2}$

   e. Potential Energy

      Energy due to position/location; $\boldsymbol{E_P = mgh}$

   f. Mechanical Energy

      Energy due to motion or location of a physical body; $\boldsymbol{ME = E_K + E_P}$

   g. Conservation of Energy

      Mechanical energy of a system remains constant before and after an event;

      $$\boldsymbol{E_{K1} + E_{P1} = E'_{K2} + E'_{P2}}$$

   h. Elastic Collision

      A collision where objects bounce off each other undamaged;

      $$m_1v_1 + m_2v_2 = m_1v'_1 + m_2v'_2$$

   i. Inelastic Collision

      A collision where objects bounce off and each is damaged OR objects collide and stick together;

      $$m_1v_1 + m_2v_2 = (m_1 + m_2)\, v'$$

UNIT 5 TEST REVIEW KEY

Instructions: *Show all of your work completely in your journal, including the equations used in variable form. Pay attention to sig figs and units; use complete sentences if applicable.*

2. What is the kinetic energy for the following objects?
   a. A 65 kg runner moving with a speed of 7.0 $^{m}/_{s}$

$$E_K = \frac{1}{2}mv^2 = \frac{1}{2}(65\text{ kg})(7.0\ ^{m}/_{s})^2$$

$$\boxed{\boldsymbol{E_K = 1600\text{ J}}}$$

   b. A 2.0 million kg space shuttle with a launch speed of 44 $^{m}/_{s}$

$$E_K = \frac{1}{2}mv^2 = \frac{1}{2}(2000000\text{ kg})(44\ ^{m}/_{s})^2$$

$$\boxed{\boldsymbol{E_K = 1.9 \times 10^9\ J}}$$

   c. A 5.0 kg bowling ball moving with a speed of 9.5 $^{m}/_{s}$

$$E_K = \frac{1}{2}mv^2 = \frac{1}{2}(5.0\text{ kg})(9.5\ ^{m}/_{s})^2$$

$$\boxed{\boldsymbol{E_K = 230\text{ J}}}$$

   d. A 75 kg skier at rest

$$E_K = \frac{1}{2}mv^2 = \frac{1}{2}(75\text{ kg})(0\ ^{m}/_{s})^2$$

$$\boxed{\boldsymbol{E_K = 0\text{ J}}}$$

3. What is the potential energy for the following objects?
   a. A 0.50 kg orange sitting on a shelf 2.0 meters off the ground

$$E_P = mgh = (0.50\text{ kg})\left(9.80\ ^{m}/_{s^2}\right)(2.0\text{ m})$$

$$\boxed{\boldsymbol{E_P = 9.8\text{ J}}}$$

   b. A 68 kg snowboarder sitting on a ramp 15 meters high

$$E_P = mgh = (68\text{ kg})\left(9.80\ ^{m}/_{s^2}\right)(15\text{ m})$$

$$\boxed{\boldsymbol{E_P = 1.0 \times 10^4\text{ J}}}$$

   c. A 1200 kg car parked in a garage 6 stories up (21 meters)

$$E_P = mgh = (1200\text{ kg})\left(9.80\ ^{m}/_{s^2}\right)(21\text{ m})$$

$$\boldsymbol{E_P = 2.5 \times 10^5\ \mathrm{J}}$$

d. A 16 kg box sitting on the floor

$$E_P = mgh = (16\ \mathrm{kg})\left(9.80\ ^{\mathrm{m}}/_{\mathrm{s}^2}\right)(0\ \mathrm{m})$$

$$\boldsymbol{E_P = 0\ \mathrm{J}}$$

4. You decide to apply your vast knowledge of physics to baseball. You swing the bat and, oops, it's a pop up. The 0.145 kg ball starts straight up off the bat at 35 $^{\mathrm{m}}/_{\mathrm{s}}$.
   a. How much kinetic energy does the ball have initially? At the top?

$$E_{K(1)} = \frac{1}{2}mv^2 = \frac{1}{2}(0.145\ \mathrm{kg})(35\ ^{\mathrm{m}}/_{\mathrm{s}})^2$$

$$\boldsymbol{E_{K(1)} = 89\ \mathrm{J}}$$

$$\boldsymbol{E'_{K(2)} = 0\ \mathrm{J}}$$

   b. At the top, what is the ball's potential energy?

$$E_{K1} + E_{P1} = E'_{K2} + E'_{P2} \rightsquigarrow 89\ \mathrm{J} + 0 = 0 + E'_{P2}$$

$$\boldsymbol{E'_{P2} = 89\ \mathrm{J}}$$

   c. The catcher catches the ball. Just before it hits, what is the ball's kinetic energy? Potential energy?

   Kinetic energy is conserved in an elastic collision. Thus:

$$\boldsymbol{E_K = 89\ \mathrm{J}}$$

$$\boldsymbol{E_P = 0\ \mathrm{J}}$$

5. You go next door from the baseball field and find the local pool. You climb up onto the 10. m platform to take a dive. If your mass is 50. kg:
   a. What is the change in potential energy when you climb up there?

$$\Delta E_P = E_{P(2)} - E_{P(1)} = mgh_2 - mgh_1 = (50\text{ kg})\left(9.80\ {}^{\text{m}}/_{\text{s}^2}\right)(10\text{ m}) - 0$$

$$\boxed{\boldsymbol{\Delta E_P = 4900\text{ J}}}$$

   b. You jump. How fast are you going just before striking the water 10. m below?

$$E_{K1} + E_{P1} = E'_{K2} + E'_{P2} \leadsto 0 + 4900\text{ J} = E'_{K2} + 0$$

$$E'_{K2} = 4900\text{ J}$$

$$E'_{K(2)} = \frac{1}{2}mv^2 \leadsto 4900\text{ J} = \frac{1}{2}(50\text{ kg})v^2$$

$$\boxed{\boldsymbol{v = 14\ {}^{\text{m}}/_{\text{s}}}}$$

6. A world-class Olympic athlete starts from rest on top of a 100. meter hill, skis down the incline and makes a world-record setting jump. If she has a mass of 55 kg, use the information given in the diagram to fill in the missing information.

Point A:

$$\boldsymbol{E_P} = mgh = (55\text{ kg})\left(9.80\ {}^{\text{m}}/_{\text{s}^2}\right)(100\text{ m}) = \boxed{\mathbf{53,900\ J}}$$

$$\boldsymbol{E_K} = \frac{1}{2}mv^2 = \underline{\mathbf{0\ J}}$$

$$\boxed{ME = E_K + E_P = 53{,}900\text{ J}}$$

Point C:

$$ME = constant = \underline{53{,}900\text{ J}}$$

$$\boldsymbol{E_P} = mgh = (55\text{ kg})\left(9.80\ {}^{\text{m}}/_{\text{s}^2}\right)(30\text{ m}) = \boxed{\mathbf{16,170\ J}}$$

$$ME = E_K + E_P \leadsto \boldsymbol{E_K} = ME - E_P = 53900\text{ J} - 16170\text{ J} = \boxed{\mathbf{37,730\ J}}$$

Point D:

$$ME = constant = \underline{53{,}900\text{ J}}$$

$$\underline{E_K = 22{,}000\text{ J}}$$

$$ME = E_K + E_P \leadsto \boldsymbol{E_P} = ME - E_K = 53900\text{ J} - 22000\text{ J} = \boxed{\mathbf{31,900\ J}}$$

$$E_P = mgh \leadsto \boldsymbol{h} = \frac{E_P}{mg} = \frac{31900\text{ J}}{(55\text{ kg})\left(9.80\ {}^{\text{m}}/_{\text{s}^2}\right)} = \boxed{\mathbf{59\ m}}$$

Point E:

$$ME = constant = \underline{53{,}900\text{ J}}$$

$$\underline{\boldsymbol{E_P} = \mathbf{0\ J}}$$

$$ME = E_K + E_P \leadsto \boldsymbol{E_K} = \boxed{\mathbf{53,900\ J}}$$

a. Calculate her velocity at points B and C

Point B *(equivalent to point D since they're at the same height!)***:**

$$E_K = \frac{1}{2}mv^2 = 22{,}000\text{ J}$$

$$v_B = \sqrt{\frac{2E_{K(B)}}{m}} = \sqrt{\frac{2(22000\text{ J})}{(55\text{ kg})}}$$

$$\boxed{v_B = 28\,^{\text{m}}/_{\text{s}}}$$

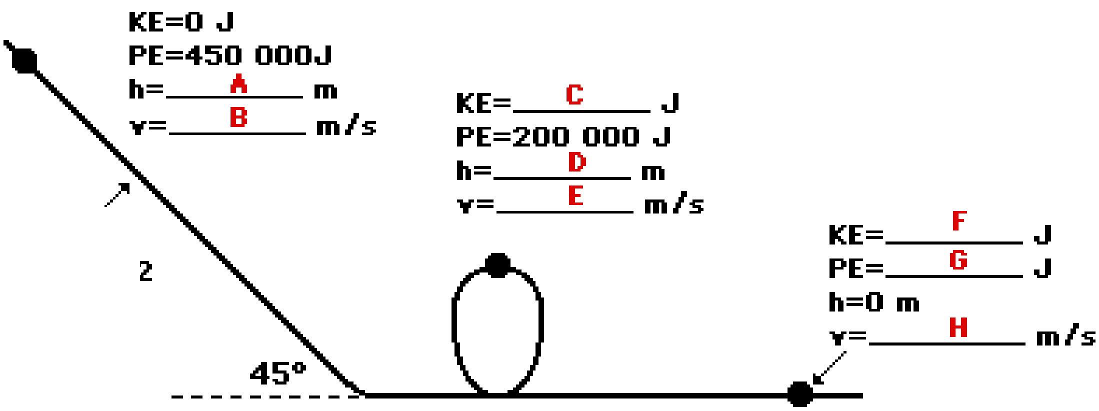
Point C:

$$E_K = \frac{1}{2}mv^2 = 37{,}730\text{ J}$$

$$v_C = \sqrt{\frac{2E_{K(C)}}{m}} = \sqrt{\frac{2(37730\text{ J})}{(55\text{ kg})}}$$

$$\boxed{v_C = 37\,^{\text{m}}/_{\text{s}}}$$

7. Use the law of conservation of energy to fill in the blanks at the various marked positions for a 1000. kg roller coaster car.



A. $E_P = mgh \rightsquigarrow h = \frac{E_P}{mg} = \frac{450000\text{ J}}{(1000\text{ kg})\left(9.80\,^{\text{m}}/_{\text{s}^2}\right)} \rightsquigarrow \boxed{h = 46\text{ m}}$

B. $E_K = 0 \rightsquigarrow \boxed{v_B = 0\,^{\text{m}}/_{\text{s}}}$

C. $ME = E_K + E_P \rightsquigarrow E_K = ME - E_P = 450000\text{ J} - 200000\text{ J} \rightsquigarrow \boxed{E_K = 250{,}000\text{ J}}$

D. $E_P = mgh \rightsquigarrow h = \frac{E_P}{mg} = \frac{200000\text{ J}}{(1000\text{ kg})\left(9.80\,^{\text{m}}/_{\text{s}^2}\right)} \rightsquigarrow \boxed{h = 20.\text{ m}}$

E. $E_K = \frac{1}{2}mv^2 = 200{,}000 \rightsquigarrow v_B = \sqrt{\frac{2E_{K(B)}}{m}} = \sqrt{\frac{2(250000\text{ J})}{(1000\text{ kg})}} \rightsquigarrow \boxed{v_B = 22\,^{\text{m}}/_{\text{s}}}$

F. $ME = E_K + E_P \rightsquigarrow \boxed{E_K = 450{,}000\text{ J}}$

G. $E_P = mgh \rightsquigarrow \boxed{E_P = 0\text{ J}}$

H. $E_K = \frac{1}{2}mv^2 = 400{,}000 \rightsquigarrow v_B = \sqrt{\frac{2E_{K(B)}}{m}} = \sqrt{\frac{2(450000\text{ J})}{(1000\text{ kg})}} \rightsquigarrow \boxed{v_B = 30.\,^{\text{m}}/_{\text{s}}}$

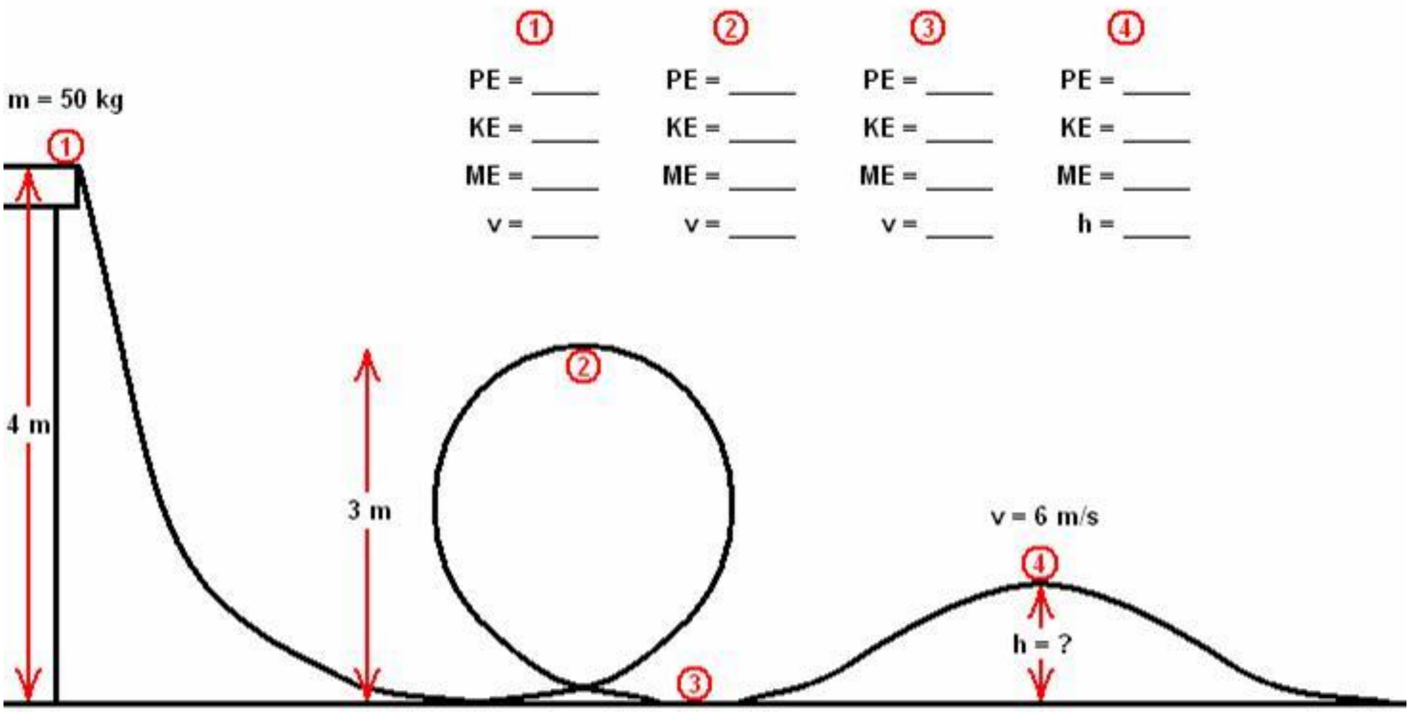
TYING IT ALL TOGETHER: REFRESHER FOR UNIT 5 KEY

1. You are rolling bowling balls toward each other for fun (like physics teachers do in their spare time) at Lucky Strike Lanes. You take an 8.0 kg ball and roll it at 2.0 $^{m}/_{s}$ toward a 12 kg bowling ball at rest. If the 12 kg ball has a final velocity of 1.5 $^{m}/_{s}$, calculate the velocity of the 8.0 kg ball. What type of collision is this?

   This is an elastic collision:

$$p_{before} = p_{after} \rightsquigarrow m_1v_1 + m_2v_2 = m_1v'_1 + m_2v'_2$$
$$(8.0\text{ kg})(2.0\ ^{m}/_{s}) + 0 = (8.0\text{ kg})v'_1 + (12\text{ kg})(1.5\ ^{m}/_{s})$$
$$(16\text{ kg}\ ^{m}/_{s}) - (18\text{ kg}\ ^{m}/_{s}) = -2.0\text{ kg}\ ^{m}/_{s} = (8.0\text{ kg})v'_1$$
$$\boxed{\boldsymbol{v'_1 = -0.25\ ^{m}/_{s}}}$$

2. Use conservation of energy to fill in the blanks for the diagram below. Show all of your work!



Point 1:

$$E_P = mgh = (50\text{ kg})\left(9.80\ ^{m}/_{s^2}\right)(4\text{ m}) = \boxed{1960\text{ J}}$$
$$E_K = \frac{1}{2}mv^2 = \boxed{0\text{ J}} \rightsquigarrow \boxed{v = 0\ ^{m}/_{s}}$$
$$ME = E_K + E_P = \boxed{1960\text{ J}}$$

Point 2:

$$\boxed{ME = constant = 1960\text{ J}}$$

$$E_P = mgh = (50\text{ kg})\left(9.80\ {}^{\text{m}}/_{\text{s}^2}\right)(3\text{ m}) = \boxed{1470\text{ J}}$$

$$ME = E_K + E_P \rightsquigarrow E_K = ME - E_P = 1960\text{ J} - 1470\text{ J} = \boxed{490\text{ J}} = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2E_K}{m}} = \sqrt{\frac{2(490\text{ J})}{(50\text{ kg})}} = \boxed{4.4\ {}^{\text{m}}/_{\text{s}}}$$

Point 3:

$$\boxed{ME = constant = 1960\text{ J}}$$

$$E_P = mgh = (50\text{ kg})\left(9.80\ {}^{\text{m}}/_{\text{s}^2}\right)(0\text{ m}) = \boxed{0\text{ J}}$$

$$\boxed{E_K = 1960\text{ J}} = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2E_K}{m}} = \sqrt{\frac{2(1960\text{ J})}{(50\text{ kg})}} = \boxed{8.9\ {}^{\text{m}}/_{\text{s}}}$$

Point 4:

$$\boxed{ME = constant = 1960\text{ J}}$$

$$E_K = \frac{1}{2}mv^2 = \frac{1}{2}(50\text{ kg})(6\ {}^{\text{m}}/_{\text{s}})^2 = \boxed{900\text{ J}}$$

$$ME = E_K + E_P \rightsquigarrow E_P = ME - E_K = 1960\text{ J} - 900\text{ J} = \boxed{1060\text{ J}} = mgh$$

$$h = \frac{E_P}{mg} = \frac{1060\text{ J}}{(50\text{ kg})\left(9.80\ {}^{\text{m}}/_{\text{s}^2}\right)} = \boxed{2.2\text{ m}}$$

3. In ballistics labs, the muzzle velocity of guns (the velocity of the bullet right as it leaves the gun) is often found by firing the bullet into a massive block of wood on a frictionless surface and measuring the final velocity of the block.
   a. What type of collision is this?

      Inelastic collision

   b. Given that the mass of the bullet is 13 grams, the mass of the block is 4.0 kg and the final velocity of the block with the embedded bullet is 1.2 ${}^{\text{m}}/_{\text{s}}$, find the initial velocity of the bullet.

$$p_{before} = p_{after} \rightsquigarrow m_1v_1 + m_2v_2 = (m_1 + m_2)\,v'$$

$$(0.013\text{ kg})v_1 + (4.0\text{ kg})(0\ {}^{\text{m}}/_{\text{s}}) = (0.013\text{ kg} + 4.0\text{ kg})(1.2\ {}^{\text{m}}/_{\text{s}})$$
$$(0.013\text{ kg})v_1 = 4.8\text{ kg}\,{}^{\text{m}}/_{\text{s}}$$
$$\boxed{\boldsymbol{v_1 = 370\ {}^{\text{m}}/_{\text{s}}}}$$

c. What is the magnitude of change in momentum experienced by the bullet just after impact?

$$\Delta p = m \cdot \Delta v = m(v_2 - v_1) = (0.013\text{ kg})(1.2\,{}^{\text{m}}/_{\text{s}} - 370\,{}^{\text{m}}/_{\text{s}})$$

$$\boxed{\boldsymbol{\Delta p = 4.8\ \text{N}\cdot\text{s}}}$$

d. If the bullet slows to a stop in 0.090 seconds, what is the magnitude of average **force** on the bullet?

$$I = \Delta p = F \cdot \Delta t \rightsquigarrow F = \frac{\Delta p}{\Delta t}$$

$$F = \frac{4.8\text{ N}\cdot\text{s}}{0.090\text{ s}}$$

$$\boxed{\boldsymbol{F = 53\text{ N}}}$$

e. Describe how momentum and energy are conserved in this situation.

Kinetic energy is not conserved (since it's an inelastic collision). Mechanical energy is converted into another form (most likely sound and heat) so energy is conserved overall. Momentum of the system overall is conserved; we must consider the momentum of the bullet AND the block of wood.

4. A 1200 kg car is crash-tested against a rigid wall. The car is accelerated by a cable underneath it, which provides a constant force of 500. N for a distance of 15.0 m.
   a. What is the velocity just before it hits the wall?

$$W = \Delta E_K \rightsquigarrow F \cdot d = \frac{1}{2}m({v_2}^2 - {v_1}^2)$$
$$v = \sqrt{\frac{2(F \cdot d)}{m}} = \sqrt{\frac{2(500\text{ N})(15.0\text{ m})}{1200\text{ kg}}}$$
$$\boxed{\boldsymbol{v = 3.54\ {}^{\text{m}}/_{\text{s}}}}$$

   b. The car's "crumple zone" crumples 2.30 m upon impact. What is the force the car experiences upon impact?

$$W = \Delta E_K \rightsquigarrow F \cdot d = \frac{1}{2}m({v_2}^2 - {v_1}^2)$$
$$F = \frac{\frac{1}{2}m({v_2}^2 - {v_1}^2)}{d} = \frac{\frac{1}{2}(1200\text{ kg})(0^2 - (3.54\,{}^{\text{m}}/_{\text{s}})^2)}{(2.30\text{ m})}$$
$$\boxed{\boldsymbol{F = -3210\text{ N}}}$$

5. Pat is ready for spring training! The ball is pitched at 45 $^{\mathrm{m}}/_{\mathrm{s}}$ and he swings his bat with an initial speed of 31 $^{\mathrm{m}}/_{\mathrm{s}}$. After the bat and the ball collide, the ball leaves the bat at homerun velocity, 67 $^{\mathrm{m}}/_{\mathrm{s}}$. The time of contact is 0.0015 sec. The mass of the bat is 1.0 kg and the mass of the ball is 0.14 kg.
   a. What is the change in momentum of the baseball?

$$\Delta p = m \cdot \Delta v = m(v_2 - v_1) = (0.14\ \mathrm{kg})(67\ ^{\mathrm{m}}/_{\mathrm{s}} - -45\ ^{\mathrm{m}}/_{\mathrm{s}})$$
$$\boxed{\boldsymbol{\Delta p = 15.7\ \mathrm{N \cdot s}}}$$

   b. What is the force of impact of the bat against the ball?

$$I = \Delta p = 15.7\ \mathrm{N \cdot s}$$
$$I = \Delta p = F \cdot \Delta t \leadsto F = \frac{I}{\Delta t}$$
$$F = \frac{15.7\ \mathrm{N \cdot s}}{0.0015\ \mathrm{s}}$$
$$\boxed{\boldsymbol{F = 10,500\ \mathrm{N}}}$$

   c. By how much is the bat slowed down by the impact?

$$I = \Delta p = m \cdot \Delta v \leadsto \Delta v = \frac{I}{m}$$
$$\Delta v = \frac{15.7\ \mathrm{N \cdot s}}{1.0\ \mathrm{kg}}$$
$$\boxed{\boldsymbol{\Delta v = 15.7\ ^{\mathrm{m}}/_{\mathrm{s}}}}$$

6. Patty is looking to play a trick on Pat by dropping a water balloon on his head. Her plan is to climb a tree, sit on a branch and drop the water balloon as Pat walks underneath. Sounds good, huh? ☺
   a. If she carries this 0.75 kg balloon up a tree 15 m vertically, how much work has she done to the balloon?

$$W = \Delta E_P = mg(h_2 - h_1) = (0.75\ \mathrm{kg})\left(9.80\ ^{\mathrm{m}}/_{\mathrm{s}^2}\right)(15\ \mathrm{m} - 0\ \mathrm{m})$$
$$\boxed{\boldsymbol{W = 110\ \mathrm{N \cdot m}}}$$

   b. When Patty drops the balloon on Pat's head (approximately 2.0 m above the ground), how fast will the balloon be traveling? *(Hint: Use energy equations!)*

$$E_{K1} + E_{P1} = E'_{K2} + E'_{P2}$$
$$0 + 110\ \mathrm{J} = \frac{1}{2}m{v_2}^2 + mgh_2 = \frac{1}{2}(0.75\ \mathrm{kg}){v_2}^2 + (0.75\ \mathrm{kg})\left(9.80\ ^{\mathrm{m}}/_{\mathrm{s}^2}\right)(2.0\ \mathrm{m})$$
$$\boxed{\boldsymbol{v_2 = 16\ ^{\mathrm{m}}/_{\mathrm{s}}}}$$

   c. If Pat thinks quick, dodges and catches the balloon with a downward motion of his hands, such that he exerts a constant force on the balloon for 0.30 seconds, what is the magnitude of this force? *(Hint: think impulse!)*

$$I = \Delta p \leadsto F \cdot \Delta t = m(v_2 - v_1)$$
$$F = \frac{m(v_2 - v_1)}{\Delta t} = \frac{(0.75\ \mathrm{kg})(0 - 16\ ^{\mathrm{m}}/_{\mathrm{s}})}{(0.30\ \mathrm{s})}$$
$$\boxed{\boldsymbol{F = -40\ \mathrm{N}}}$$

d. Why would the balloon break if it hit Pat's head, but probably not if he caught it with a downward motion? Use appropriate physics terminology in your answer.

By catching it with a downward motion, he is increasing the time of contact. Our impulse equation shows us that this will decrease the force, thus making it less likely the balloon will break.

UNIT 5 TEST REVIEW KEY

Instructions: *Show all of your work completely in your journal, including the equations used in variable form. Pay attention to sig figs and units; use complete sentences if applicable.*

1. In your own words, define the following terms. Include the conceptual definition, equation(s) and unit(s):
   a. Momentum

      Momentum is similar to inertia in motion; $p = m \cdot v$***; the units are*** $kg\,{}^{m}/_{s}$ ***or*** $N \cdot s$***.***

   b. Impulse

      Impulse is a force applied over a time interval; $I = F\Delta t = \Delta p$***; the units are*** $kg\,{}^{m}/_{s}$ ***or*** $N \cdot s$ ***.***

   c. Conservation of Momentum

      The momentum of a system before an event is equal to momentum afterward. The units are $kg\,{}^{m}/_{s}$ ***or*** $N \cdot s$***.***

      $$p_{before} = p'_{after}$$

   d. Kinetic Energy

      Energy due to motion; $E_K = \frac{1}{2}mv^2$***; the units are Joules (*** J ***).***

   e. Potential Energy

      Energy due to position/location; $E_P = mgh$***; the units are Joules (*** J ***).***

   f. Mechanical Energy

      Energy due to motion or location of a physical body; $ME = E_K + E_P$***; the units are Joules (*** J ***).***

   g. Conservation of Energy

      Mechanical energy of a system remains constant before and after an event; the units are Joules (J ***).***

      $$E_{K1} + E_{P1} = E'_{K2} + E'_{P2}$$

   h. Work

      Work is defined as the transfer of energy through motion. Its equation is $W = F \cdot d \cdot \cos\theta$ ***and the units are N·m or Joules (*** J ***).***

   i. Work-Energy Theorem

      Work is directly related to a change in kinetic energy. This is called the work-kinetic energy theorem. The equation for this is $W = \Delta E_K = E_{K2} - E_{K1}$ ***and the units are N·m or Joules (*** J ***).***

   j. Power

      Power is defined as the rate at which work is done. Its equation is $P = \frac{W}{t}$ ***and the units are*** ${}^{J}/_{s}$ ***or Watts (W).***

2. Compare and contrast elastic and inelastic collisions. Make sure that you discuss what quantities are conserved in these types of collisions!

   An elastic collision is one in which objects bounce off each other undamaged; momentum and kinetic energy are conserved. An inelastic collision is one in which objects bounce off and each is damaged OR objects collide and stick together; momentum is conserved, but kinetic energy is NOT conserved.

3. What are the relationships between the following quantities (i.e. – inverse, directly proportional, etc.)?
   a. Momentum and Velocity

      Directly: $p \propto v$

   b. Impulse and Time

      Directly: $I \propto \Delta t$

   c. Force and Time

      Inversely: $F \propto \frac{1}{\Delta t}$

   d. Impulse and Δ Momentum

      Directly: $I \propto \Delta p$

   e. Kinetic and Potential Energy

      Inversely: $E_K \propto \frac{1}{E_P}$

   f. Kinetic Energy and Velocity

      Squared: $E_K \propto v^2$

   g. Potential Energy and Height

      Directly: $E_P \propto h$

   h. Work and Force

      Directly: $W \propto F$

   i. Work and Δ Kinetic Energy

      Directly: $W \propto \Delta E_K$

   j. Power and Work

      Directly: $W \propto P$

   k. Power and Time

      Inversely: $P \propto \frac{1}{t}$

WAVES, WAVE BEHAVIOR, GEOPHYSICS AND SOUND REVIEW ANSWER KEY

***Instructions**: Show all of your work completely in your journal, including the equations used in variable form. Pay attention to sig figs and units; use complete sentences if applicable.*

4. If you fire a bullet from a pistol and a revolver with a longer barrel, which will have greater velocity when it leaves the barrel? Why?

   Because the force stays the same and the time it is applied over increases, the impulse increases. Since impulse is directly proportional to change in velocity, this means it will have a greater velocity.

5. You are having a water balloon fight with your friends. Why are your water balloons more likely to break if you hit a friend who is not prepared versus letting them catch it?

   A friend who catches the balloon will most likely move their hand with the motion of the balloon, thus increasing the time over which the balloon comes to rest. This means that the force experienced by the balloon has a smaller magnitude and is less likely to break.

6. Which is more damaging: running into a solid wall or colliding head on (with the same speed from the wall) with an identical car moving at the same speed? Why?

   They are both equally damaging! Think about the Myth Busters clip: Newton's 3rd law means that they are both experiencing the same force!

7. Two skiers are moving toward each other and collide. If the come to rest at the point of impact, what do we know about their motion before the collision?

   They had equal and opposite momentums before the collision. We know this because the total momentum after their collision is 0, so it must have been 0 before! (Since we don't know their masses, we cannot say their velocities were equal and opposite. We need more information for that).

8. When we talk about work, we are looking at a force causing motion. What forces are doing work in the following situations? ***These forces must be causing the motion and in the same direction as the displacement!***
   a. A box is pushed 5 meters across the floor

      The applied push force

   b. A sky-diver falls 100 meters towards the Earth

      The force due to gravity

   c. An elevator is lifted 20 meters upward

      The of tension in the cable

9. Why is it important for work to depend on displacement versus distance? What do we know about work as a result?

   Displacement is a vector! As a result, work is independent of the path taken! All that matters is the starting and ending points!

10. Two boats of unequal mass travel across the bay at the same speed and in the same direction. If the water exerts the same frictional force on the boats, how will their stopping distances compare?

The boat with more mass will have a longer stopping distance. This is due to the work-kinetic energy theorem. More mass means more kinetic energy and thus more work. If work is greater and force is the same, the distance must be longer.

11. Basketball A and B each have a mass of 3.0 kg and are moving at 4.0 $^{m}/_{s}$.
    a. What is Basketball A's momentum? Basketball B?

$$p_A = p_B = mv = (3.0\ \text{kg})(4.0\ ^{m}/_{s})$$

$$\boxed{p_A = p_B = 12\ \text{kg}\ ^{m}/_{s}}$$

    b. If A and B are moving in the same direction, what is the momentum of the system? What if they move in opposite directions?

$$p_{total} = p_A + p_B = 12\ \text{kg}\ ^{m}/_{s} + 12\ \text{kg}\ ^{m}/_{s} = \boxed{24\ \text{kg}\ ^{m}/_{s}}$$
$$p_{total} = p_A + -p_B = 12\ \text{kg}\ ^{m}/_{s} - 12\ \text{kg}\ ^{m}/_{s} = \boxed{0\ \text{kg}\ ^{m}/_{s}}$$

12. A roller coaster cart starts at the bottom of a hill with some speed. At some point while moving up the hill, the cart has a potential energy of 80.0 J and a kinetic energy of 20.0 J.
    a. When the cart is at the top of a hill and at rest, what is its potential energy?

$$ME = constant = E_K + E_P = 80.0\ \text{J} + 20.0\ \text{J} = 100.\ \text{J}$$

At the top of the hill, velocity is 0 so kinetic energy is 0 J:

$$\boxed{E_P = 100.\ \text{J}}$$

    b. What was the initial speed of the cart at the bottom of the hill if it has a mass of 85.0 kg?

At the bottom of the hill, height is 0 m so potential energy is 0 J:

$$E_P = 100.\ \text{J} = \frac{1}{2}mv^2$$
$$v = \sqrt{\frac{2E_K}{m}} = \sqrt{\frac{2(100\ \text{J})}{(85\ \text{kg})}}$$
$$\boxed{v = 1.53\ ^{m}/_{s}}$$

13. An ice skater is at rest on the ice when she catches a prop that her partner threw to her. If the skater has a mass of 55 kg, the prop is 7.0 kg, and it was initially moving towards her at 18 $^{m}/_{s}$, how fast will the skater with the prop be moving after she catches the prop?

$$p_{before} = p_{after} \rightsquigarrow m_1v_1 + m_2v_2 = (m_1 + m_2)\,v'$$

$$0 + (7.0\ \text{kg})(18\ ^{m}/_{s}) = (55\ \text{kg} + 7.0\ \text{kg})v'$$
$$126\ \text{kg}\ ^{m}/_{s} = (62\ \text{kg})v'$$

$$\boxed{v' = 2.0\ {}^{\mathrm{m}}/_{\mathrm{s}}}$$

14. What is the work done by a 35 N force exerted at an angle of 25° to push a box of tools 15 m?

$$\boldsymbol{W = F \cdot d \cdot cos(\theta) = (35\ \mathrm{N})(15\ \mathrm{m})cos(25°)}$$

$$\boxed{\boldsymbol{W = 480\ \mathrm{N \cdot m}}}$$

15. What is the power supplied by a constant 75 N force if the object has an average speed of 12 ${}^{\mathrm{m}}/_{\mathrm{s}}$?

$$\boldsymbol{P = \frac{W}{t} = \frac{F \cdot d}{t} = F \cdot v = (75\ N)(12\ {}^{\mathrm{m}}/_{\mathrm{s}})}$$

$$\boxed{\boldsymbol{P = 9\bar{0}0\ \mathrm{W}}}$$

UNIT 6 QUIZ REVIEW: WAVES, WAVE BEHAVIOR, AND SOUND ANSWER KEY

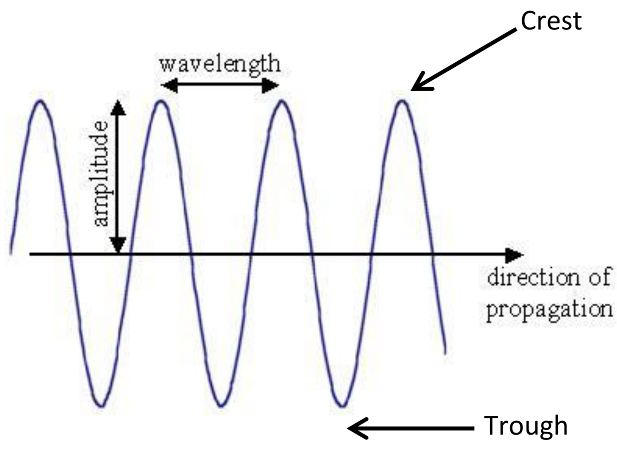
***Instructions**: Show all of your work completely in your journal, including the equations used in variable form. Pay attention to sig figs and units; use complete sentences if applicable.*

1. Define and provided examples for the following types of waves:
   a. Transverse: ***waves with particle motion perpendicular to wave propagation (i.e. – guitar strings, earthquake S-waves)***
   b. Longitudinal: ***waves with particle motion parallel to wave propagation (i.e. – sound waves, earthquake P-waves)***
   c. Surface: ***waves with particle motion perpendicular AND parallel to wave propagation, resulting in a circular motion (i.e. – water waves)***

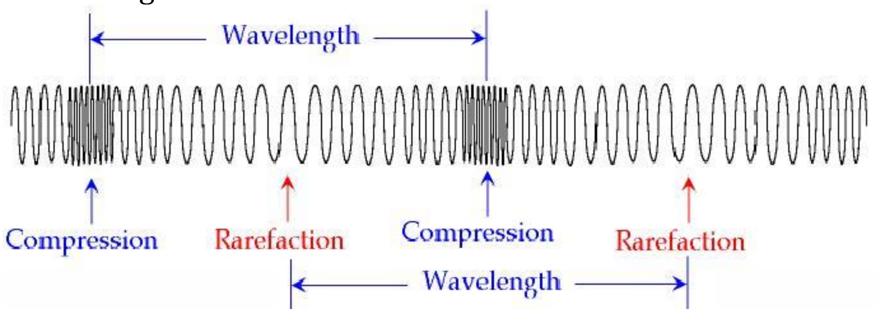
2. What is the only factor that affects the speed of a mechanical wave?
   Wave speed is a property of the medium through which the wave is travelling.

3. Define and list the variables for the following terms:
   a. Frequency: ***The number of complete cycles that pass a fixed point every second; units: Hertz (Hz)***
   b. Period: ***The amount of time required to complete on full cycle; units: seconds (s)***
   c. Wave Speed: ***The speed with which energy propagates through a medium; units: $^{m}/_{s}$***
   d. Amplitude: ***For transverse waves: amplitude is a measure of maximum displacement from equilibrium. In longitudinal waves: it is the difference in pressure between the compressions and rarefactions (perceived as volume in sound waves).***
   e. Wavelength: ***The distance from one point on a wave to the same point on the next wave (i.e.- crest to crest); units: meters (m)***
   f. Sound Intensity: ***power of sound per unit areas; units: decibels (dB)***

4. Sketch and label the following diagrams:
   a. Transverse Wave:

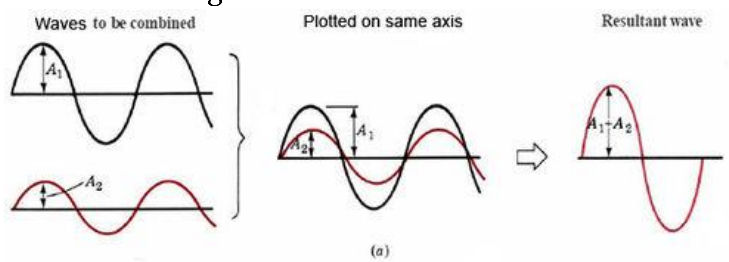


b. Longitudinal Wave:

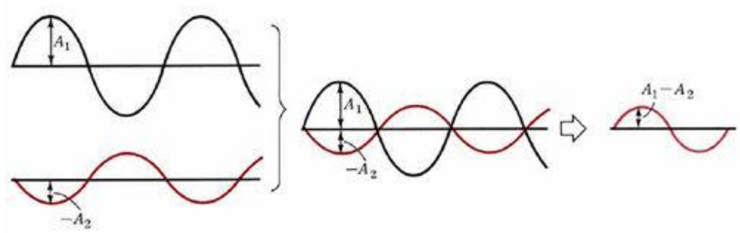


5. Define and sketch a diagram for each of the following wave behaviors:

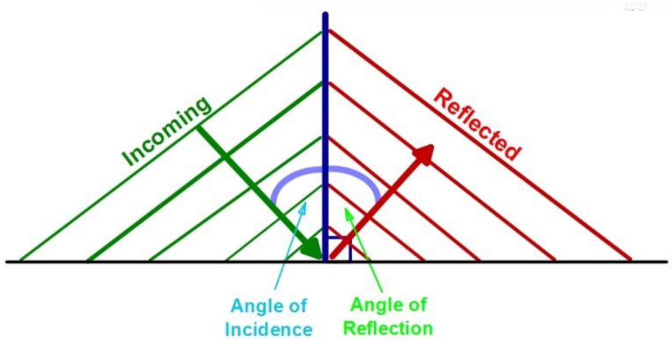
a. Constructive Interference



b. Destructive Interference



c. Reflection



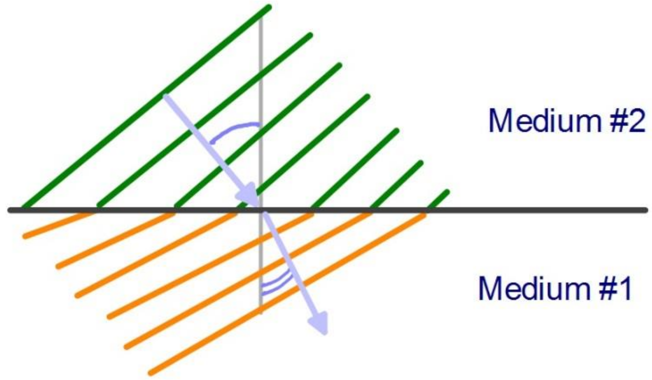
d. Fixed vs. Free End:

Incoming Wave:

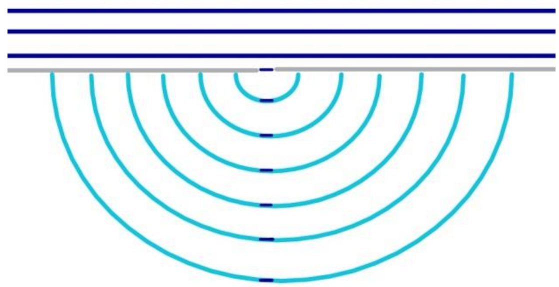
Fixed:

Free:

e. Refraction



f. Diffraction

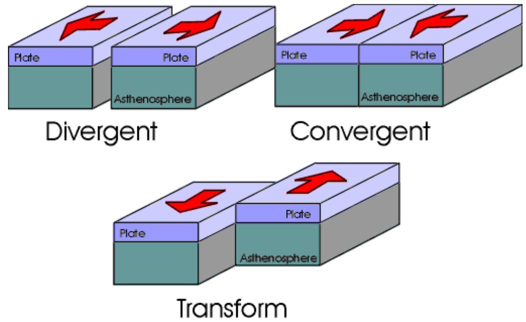


6. What is the superposition principle? What does it mean for mechanical waves?
   The superposition principle states that waves can be in the same place at the same time. To find the resultant wave's amplitude, we simply add the two waves point by point.

7. Define the following:
   a. Primary Waves: ***longitudinal waves that arrive first during an earthquake***
   b. Secondary Waves: ***transverse waves that arrive second during an earthquake***
   c. Epicenter: ***the point on the earth's surface directly above the focus***
   d. Focus: ***the point where the earthquake occurs***
   e. Earthquake: ***a sudden movement occurring to release stress that builds up between plate boundaries***
   f. Tsunami: ***long sea waves that travel up to 1000 km/hr with very long wavelengths***

8. What are the events that can cause earthquakes? Tsunamis?
   Earthquakes can be caused by tectonic activity, volcanic activity, or large shifting masses. Tsunamis can be caused by earthquakes causing tectonic displacement, volcanic eruptions causing seismic activity, landslides above or below water, or asteroids (very rare).

9. What are the 3 types of plate boundaries we learned about? How do plates move relative to each other with these types of boundaries?
   At divergent boundaries, plates are moving away from each other. At transform boundaries, plates move past each other. And at convergent boundaries, the plates are coming together. (Ocean meeting continental = subduction zone; Continental meeting continental = mountain)



10. How do seismographs work?
    This can vary by design; HOWEVER, the basics are the same. The main housing of the seismograph is fixed to the earth, so it will shake with seismic activity. The recorder is attached to a free hanging object. The inertia of the recorder keeps it from moving with the housing, thus recording the movement of the earth due to the seismic waves!

11. What's the difference between a water wave and a tsunami?
    Water waves have circular motion where tsunamis do not. This means that water waves will crest and break in shallow water. Tsunamis, on the other hand, keep building amplitude and run quickly inland like a wall of water.

12. Why do the amplitudes of tsunamis increase as they approach the shore?
    The shallower water acts as a different medium, which slows down the water in front. The back of the wave is still moving quicker, so it builds up, thus increasing the amplitude (like a traffic jam).

13. Define pitch; what wave property is it most closely related to?
    Pitch is the tone of a sound (how high or low something sounds). It is most closely associated with frequency.

14. Define loudness; what wave property is it most closely related to?
    Loudness is the brain's interpretation of pressure differences in sound waves. This is related to the amplitude of the sound wave.

15. If frequency changes, what other wave properties are changed? Are they directly or indirectly related?
    If frequency changes (and the medium is not), the period changes inversely (i.e. – if frequency increases, period decreases), as does the wavelength (also inversely).

16. How does air temperature affect the speed of sound? List an equation to support your reasoning.
    Yes! Sound travels faster in warmer air because the molecules have more kinetic energy and are thus easier to propagate through.

$$v_{sound} = 331 + 0.6T$$

17. Explain how the following parts of your ear are related to your ability to hear:

***Instructions**: Show all of your work completely in your journal, including the equations used in variable form. Pay attention to sig figs and units; use complete sentences if applicable.*

a. Eardrum: ***The eardrum vibrates when sound waves reach it; these vibrations are then carried as pressure waves to the middle ear.***
b. Hammer: ***The hammer is a small bone in the middle ear; it vibrates due to pressure waves from the eardrum.***
c. Anvil: ***The anvil is a small bone in the middle ear; it vibrates due to vibrations from the hammer bone.***
d. Stirrup: ***The stirrup is a small bone in the middle ear; it vibrates due to vibrations from the anvil bone. It then transmits pressure waves to the inner ear.***
e. Cochlea: ***The cochlea has tiny hairs connected to nerve receptors. These hairs vibrate due to the pressure wave created by the bones in the middle ear. These hairs create electrical impulses that are sent to the brain and interpreted as sound!***

18. Define the following terms:
    a. Infrasonic frequencies: ***frequencies LOWER than 20 Hz***
    b. Ultrasonic frequencies: ***frequencies HIGHER than 20,000 Hz***
    c. Subsonic speeds: ***speeds SLOWER than the speed of sound (~343 $^{m}/_{s}$)***
    d. Supersonic speeds: ***speeds FASTER than the speed of sound***

19. Define the Doppler Effect. How does the apparent frequency shift for an observer based on the motion of the source?
    The Doppler Shift is the APPARENT shift in frequency due to the relative motion of a sound source to an observer. When the source is moving TOWARDS the observer, the pitch the observer hears will be HIGHER than the source frequency and vice versa!

20. A tuning fork with a frequency of 480 Hz is played in a room with a temperature of 25°C.
    a. What is the period of the sound wave?

$$f = \frac{1}{T} \backsim T = \frac{1}{f} = \frac{1}{480\text{ Hz}}$$

$$\boxed{T = 0.00208\text{ s} = 2.08 \times 10^{-3}\text{s}}$$

    b. What is the velocity of the sound wave produced?

$$v_{sound} = 331 + 0.6T = 331 + 0.6(25℃)$$

$$\boxed{v_{sound} = 346\ {}^{\text{m}}/_{\text{s}}}$$

    c. What is the wavelength of the resulting sound wave?

$$v = f\lambda \backsim \lambda = \frac{v}{f} = \frac{346\ {}^{\text{m}}/_{\text{s}}}{480\text{ Hz}}$$

$$\boxed{\lambda = 0.721\ \text{m} = 721\ \text{mm}}$$

21. The velocity of the primary waves produced by an earthquake is 8900 $^{\text{m}}/_{\text{s}}$ and that of the secondary waves is 5100 $^{\text{m}}/_{\text{s}}$. A seismograph records the arrival of the transverse waves 74 s after the arrival of the longitudinal waves. How far away is the earthquake?

$$d = v \cdot t$$

↙ ↘

$$d_{p-wave} = v_{p-wave} \cdot t_{p-wave}$$

$$d_{s-wave} = v_{s-wave} \cdot \left(t_{p-wave} + t_{delay}\right)$$

$$d_{p-wave} = d_{s-wave}$$

$$\downarrow$$

$$v_{p-wave} \cdot t_{p-wave} = v_{s-wave} \cdot \left(t_{p-wave} + t_{delay}\right)$$

$$\downarrow$$

$$(8900\ ^{\text{m}}/_{\text{s}}) \cdot t_{p-wave} = (5100\ ^{\text{m}}/_{\text{s}}) \cdot \left(t_{p-wave} + 74\ \text{s}\right)$$

$$(8900\ ^{\text{m}}/_{\text{s}}) \cdot t_{p-wave} = (5100\ ^{\text{m}}/_{\text{s}}) \cdot t_{p-wave} + 377{,}400\ \text{m}$$

$$(3800\ ^{\text{m}}/_{\text{s}}) \cdot t_{p-wave} = 377{,}400\ \text{m}$$

$$\underline{t_{p-wave} = 99\ \text{s}}$$

$$\downarrow$$

$$d_{p-wave} = v_{p-wave} \cdot t_{p-wave} = (8900\ ^{\text{m}}/_{\text{s}}) \cdot (99\ \text{s})$$

$$\boxed{d_{p-wave} = 883{,}911\ \text{m} = 883\ \text{km}}$$

1. Define the Doppler Effect. How does the apparent frequency for sound waves shift for an observer based on the motion of the source? How does this differ from the Doppler Effect for light waves?
   The Doppler Shift is the APPARENT shift in frequency/wavelength due to the relative motion of a sound source to an observer.
   When a <u>sound</u> source is moving TOWARDS the observer, the pitch the observer hears will be HIGHER than the source frequency and vice versa!
   When a <u>light</u> source is moving TOWARDS the observer, the wavelength the observer sees will be SHORTER than the source frequency, thus the light is BLUE SHIFTED; and vice versa!

2. Define and each of the following wave behaviors and provide examples from mechanical waves, sound waves, and EM waves (such as light):
   a. Interference: ***Interference is a result of the superposition principle which states that waves can be in the same place at the same time. Constructive interference means that a wave with larger amplitude is produced; destructive interference means that a wave with small amplitude (or even 0!) is produced. We saw a mechanical wave example of this in the ripple tank demos. In sound waves, interference patterns create beat frequencies. In light waves, interference patterns in Young's double slit experiment showed that light has wave properties.***

   b. Transmission: ***Transmission occurs when some or all waves pass through a material. We saw a mechanical wave example of this in the ripple tank demo #2. An example from sound would be hearing voices from a neighboring room through the wall. An example from light would be light passing through tissue paper.***

   c. Absorption: ***Absorption occurs when part or all of a wave is blocked by a barrier. This occurs in sound proofing for some frequencies of sound. In light, an example would be subtractive color mixing; i.e. – a red rose absorbs all frequencies of light except for red.***

   d. Reflection: ***Reflection is the redirection of waves back into the same part of the medium they came from as a result of interaction with a barrier or medium change. We saw a mechanical wave example of this in the ripple tank experiment #1. In sound, this can be seen with echoes. In light, spectral reflection, such as with a mirror, reflects light rays parallel to each other. In diffuse reflection, light is scattered and thus has a halo of light, rather than a beam.***

   e. Refraction: ***Refraction is the bending of waves when they enter a new medium. We saw a mechanical wave example of this in the ripple tank experiment #2. In sound, we experience refraction with different temperatures of air. In light, we see refraction when mediums are changed according to Snell's law; this is also the reason that prisms can break white light down into the visible spectrum.***

   f. Diffraction: ***Diffraction is the bending of wave fronts into an open part of a medium and around corners of barriers. We saw a mechanical wave example of this in the ripple tank experiment #3. In sound waves, hearing someone around a corner is an***

example of diffraction. In light waves, light diffracts around clouds, creating some very cool patterns!

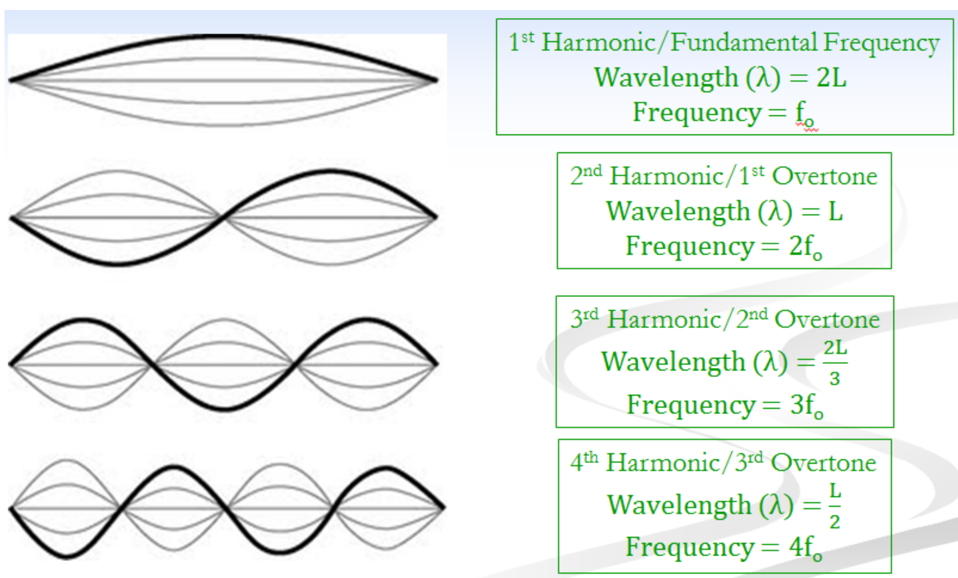
3. What is a beat frequency? Why is the pattern of beats produced?
A beat frequency is produced by sound wave interference. Repeating patterns of constructive and destructive interference when two sources have different frequencies create a pattern of loud and soft "beats." The number of beats per second is called the beat frequency and is equal to the difference in frequency of the two sources.

    a. A tuning fork has a frequency of 465 Hz. When a second tuning fork is struck, beat interference patterns occur with a beat frequency of 5 Hz. What is the lowest and highest frequency of the second fork?
    LOWEST FREQUENCY: *465Hz – 5Hz =* ***460 Hz***
    HIGHEST FREQUENCY: *465Hz + 5Hz=* ***470 Hz***

4. What is a standing wave and how is it created? What are nodes and anti-nodes?
A standing wave is created when a wave reflects back on itself. Constructive interference creates areas of maximum displacement called nodes and destructive interference created anti-nodes which remain stationary.

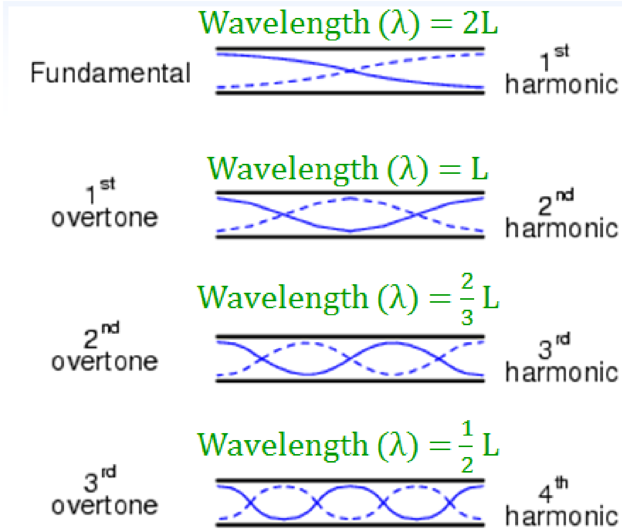
    a. Sketch standing waves in a string for the first 4 harmonics. What general equation can be applied to standing waves in a string?

$$L = \frac{n \cdot \lambda}{2}$$



5. Sketch standing waves in an open-end resonator for the first 4 harmonics. What general equation do we use for standing waves in an open pipe?

$$L = \frac{n \cdot \lambda}{2}$$



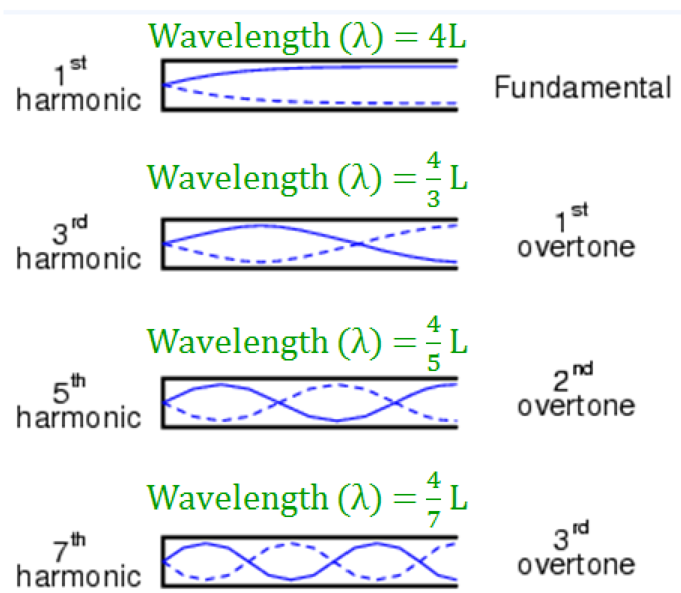
a. A flute acts as an open-end resonator. If the flute has a resonant length of 25 cm, what is the wavelength of the 3rd harmonic frequency?

$$L = \frac{n \cdot \lambda}{2} \rightsquigarrow \lambda = \frac{2 \cdot L}{n} = \frac{2(0.25\text{m})}{3}$$

$$\boxed{\lambda = 0.17\ \text{m}}$$

6. Sketch standing waves in a closed-end resonator for the first 4 harmonics. What general equation do we use for standing waves in a closed pipe?

$$L = \frac{n \cdot \lambda}{4}$$



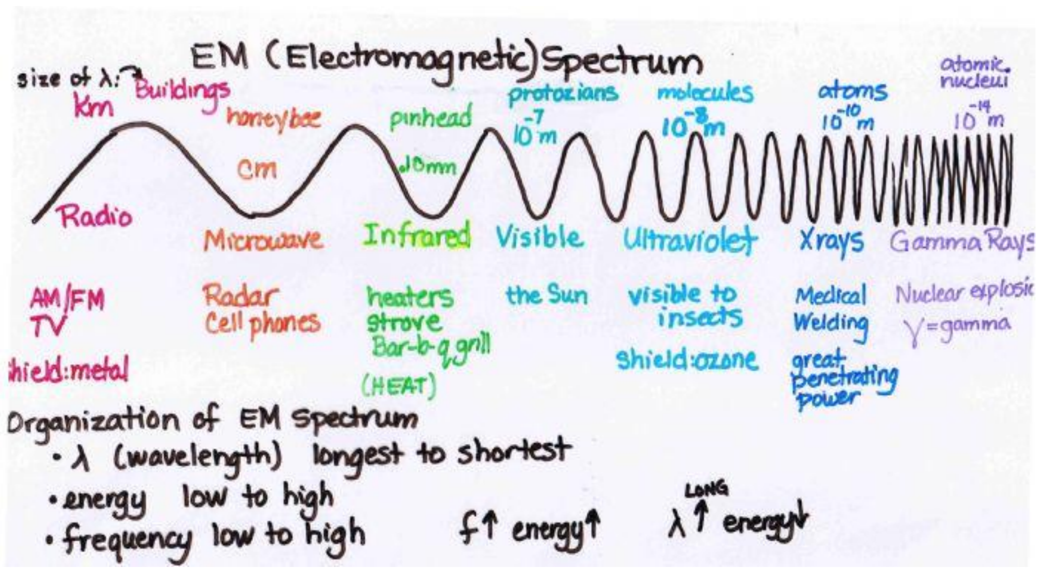
a. An organ pipe acts as a closed-end resonator. What is the length of an organ pipe which has a fundamental frequency of 18 Hz?

$$\boldsymbol{v = f\lambda \rightsquigarrow \lambda = \frac{v}{f} = \frac{343\ \mathrm{m/s}}{18\ \mathrm{Hz}} = 19\ \mathrm{m}}$$

$$\boldsymbol{L = \frac{n \cdot \lambda}{4} = \frac{1(19\ \mathrm{m})}{4}}$$

$$\boxed{\boldsymbol{L = 4.8\ \mathrm{m}}}$$

7. What is an EM Wave? What is the Electromagnetic Spectrum? How is it laid out in terms of frequency, wavelength, and energy?
An electromagnetic wave is a caused by simultaneous oscillations in the electric and magnetic fields. It is a 2 dimensional transverse wave. The EM spectrum organizes different types of EM waves from longest to shortest wavelengths. Waves are also arranged in order from lowest to highest energy and frequencies.



8. List applications of the following types of EM waves:
   a. Gamma Rays: ***nuclear reaction product, cancer treatment, sterilization***
   b. X-Rays: ***medical imaging, airport security, deep space telescopes***
   c. Ultraviolet Rays: ***tanning, forgery prevention, sterilization***
   d. Visible Light: ***eyes, lasers, technology such as CD and DVD players, printers***
   e. Infrared Radiation: ***remote controls, healing injuries, thermal imaging***
   f. Microwaves: ***cooking, cell phones, radar, speed cameras***
   g. Radio Waves: ***communication***

9. What is the speed of light? If it is constant, why does it sometimes seem to change with the medium?
The speed of light is constant: $c = 3.00 \times 10^8$ m/s. Sometimes it seems slower in a medium because it has to take a longer path to get through the medium. The denser a medium is, the more the light will bounce around while passing through it! (Think about the presidential analogy video we saw in class)

10. Explain Snell's Law and index of refraction.
Snell's law is the law of refraction for light waves. The index of refraction is a property of a medium that affects the angle of refraction.
    a. List the equations for each and explain each of the variables.

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

Where n_1 is the index of refraction in the incident medium, θ_1 is the incident angle, n_2 is the index of refraction in the refractive medium, and θ_2 is the refractive angle.

$$n = \frac{c}{v}$$

Where n is the index of refraction, c is the speed of light, and v is the speed of light in the medium for which we are determining the index of refraction.

    b. A beam of light passes from water into glass. The index of refraction for water (n_{water}) is 1.33 and the angle of incidence is 25°. If the angle of refraction is 22°, what is the index of refraction for glass?

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \rightsquigarrow n_2 = \frac{n_1 \sin\theta_1}{\sin\theta_2} = \frac{1.33 \sin 25°}{\sin 22°}$$

$$\boxed{n_2 = 1.52}$$

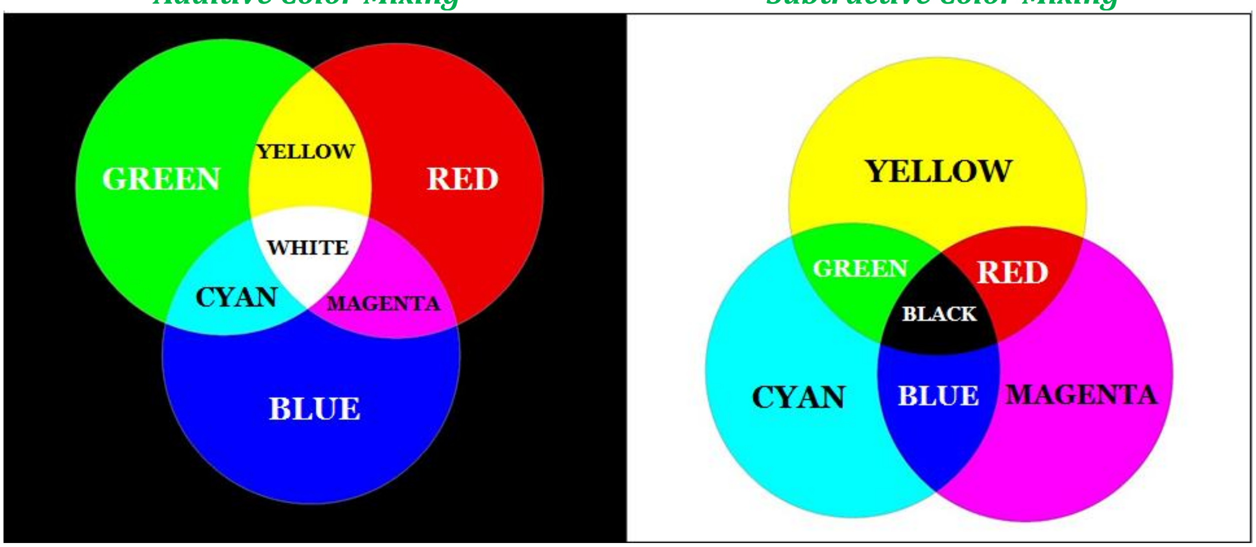
11. Define total internal reflection.
Total internal reflection occurs when light falls on a surface of a less optically dense medium at an angle of incidence equal to or greater than the critical angle of the substance. There is no refracted ray; occurs at critical angle.
    a. What is the critical angle and how does it relate to total internal reflection?
    The critical angle is the angle of incidence in the more optically dense medium at which the angle of refraction in the less optically dense medium is exactly 90°. If the incident angle of an incoming light beam is greater than the critical angle, total internal reflection will occur.
    b. What are some applications of total internal reflection?
    Total internal reflection is used in fiber optic technology and binoculars.

12. What is the range of the visible spectrum from shortest to longest wavelength?
400 (violet) – 700 nm (red)
    a. What colors do we typically say make up the visible spectrum?
    ROYGBIV
    b. Is white a color of light? Why or why not?
    NO! White light is the presence of all color of the visible spectrum.
    c. Why are sunsets red? Why is the sky blue?
    Sunsets are red because red wavelengths of light survive being scattered by the air before reaching our eyes. The sky is blue because blue wavelengths of light are scattered by the air molecules, so when we look up, we see all the scattered blue light!
    d. What is the relationship between energy and frequency for a photon?
    As the energy of a photon increases, its frequency increases as well.

13. How can we use prisms to prove white light is made up of all the visible colors of light? What is dispersion?
Prisms break white light into the visible spectrum. They do this using refraction and dispersion. Dispersion is a phenomenon in which the angle of refraction depends on the wavelength of light. This means that different colors of light bend at different angles, thus creating the visible spectrum.

14. Draw and label a diagram for both additive and subtractive color mixing.

Additive Color Mixing | *Subtractive Color Mixing*



    a. What are examples of additive color mixing? Subtractive color mixing?
    Additive color mixing applies to light and our eyes. Subtractive color mixing happens with colored pigments, inks, and dyes.
    b. What are the primary, secondary, and complementary colors of light?
    The primary colors of light are red, blue, and green.
    The secondary colors of light are cyan, yellow, and magenta.
    The complementary colors are blue and yellow; green and magenta; & red and cyan.

c. What are the primary and secondary colors of ink/pigment?
The primary colors of pigment/ink are cyan, yellow, and magenta.
The secondary colors of pigment/ink are red, blue, and green.

d. Is black a color of light? Why or why not?
Black is a lack of color/light! Thus it is not a color at all.

e. If you shine a red flashlight and a blue flashlight at a white wall, what color will you see where the flashlight beams overlap?
This is additive color mixing: red + blue = MAGENTA light

f. What color is a yellow ball when viewed under cyan light?
The ball is yellow because of subtractive color mixing: blue light is subtracted/absorbed. We see yellow light because of additive color mixing: green and red light are reflected. Cyan light is a mixture of blue and green light; since blue is absorbed, we will see the ball as GREEN.

15. You decide to kick off your summer with a relaxing cruise around Lake Sammamish in your friend's boat. But a storm rolls in to ruin your fun!

a. If the temperature drops to 15.0°C, what is the speed of sound in air on the lake?

$$v_{sound} = 331 + 0.6T = 331 + 0.6(15℃)$$

$$\boxed{v_{sound} = 34\bar{0}\ {}^{\mathrm{m}}/_{\mathrm{s}}}$$

b. You see a big flash of lightening and count 2.60 seconds before hearing the thunder. How far away is the storm?

$$v = \frac{d}{t} \rightsquigarrow d = v \cdot t = (340\ {}^{\mathrm{m}}/_{\mathrm{s}})(2.60\ \mathrm{s})$$

$$\boxed{d = 884\ \mathrm{m}}$$

c. How far did the flash of lightening travel in the 2.60 seconds it took for the sound wave from the thunder to reach you?

$$v = \frac{d}{t} \rightsquigarrow d = v \cdot t = (3.00 \times 10^8\ {}^{\mathrm{m}}/_{\mathrm{s}})(2.60\ \mathrm{s})$$

$$\boxed{d = 780{,}000{,}000 = 7.80 \times 10^8\ \mathrm{m}}$$

d. If the rumble of the thunder had an average frequency of 95 Hz, what was the wavelength of the sound wave?

$$v = f\lambda \rightsquigarrow \lambda = \frac{v}{f} = \frac{340\ {}^{\mathrm{m}}/_{\mathrm{s}}}{95\ \mathrm{Hz}}$$

$$\boxed{\lambda = 3.58\ \mathrm{m}}$$

e. What is the period of the thunder's sound wave?

$$f = \frac{1}{T} \rightsquigarrow T = \frac{1}{f} = \frac{1}{95\ \text{Hz}}$$

$$\boxed{T = 0.0105\ \text{s} = 1.05 \times 10^{-2}\text{s}}$$

PHYSICAL CONSTANTS

$g = 9.80\ ^{m}/_{s^2}$

$v_{sound} = 343\ ^{m}/_{s}$

$I_o = 1 \times 10^{-12}\ ^{W}/_{m^2}$

$v_{light} = 3.00 \times 10^{8}\ ^{m}/_{s}$

UNIT 1 CONVERSION FACTORS:

1 mi = 1609 m
1 in = 2.54 cm
1 hr = 3600 s

1 kg = 2.2 lbs
1 lb = 454 g
1 cm^3 = 1 mL

UNIT 2 (KINEMATICS) EQUATIONS:

Linear Motion:

$\overline{\boldsymbol{v}} = \frac{\boldsymbol{d}}{t}$ so $t = \frac{\boldsymbol{d}}{\overline{\boldsymbol{v}}}$ and $\boldsymbol{d} = \overline{\boldsymbol{v}} \cdot t$

$$\overline{\boldsymbol{v}} = \frac{\boldsymbol{v_1} + \boldsymbol{v_2}}{2}$$

$$\Delta\boldsymbol{v} = \boldsymbol{v_2} - \boldsymbol{v_1}$$

$$\boldsymbol{a} = \frac{\boldsymbol{v_2} - \boldsymbol{v_1}}{t}$$

$$\boldsymbol{v_2} = \boldsymbol{v_1} + \boldsymbol{a}t$$

$$\boldsymbol{v_2}^2 = \boldsymbol{v_1}^2 + 2\boldsymbol{ad}$$

$$\boldsymbol{d} = \boldsymbol{v_1}t + \frac{1}{2}\boldsymbol{a}t^2$$

Free Fall Motion:

$$\boldsymbol{v} = \boldsymbol{g} \cdot t$$

$$\boldsymbol{d} = \frac{1}{2}\boldsymbol{g}t^2$$

UNIT 3 (VECTORS AND PROJECTILES) EQUATIONS:

Vector Addition:

$$\sin\theta = \frac{opposite}{hypotenuse} \qquad \cos\theta = \frac{adjacent}{hypotenuse} \qquad \tan\theta = \frac{opposite}{adjacent}$$

$$a^2 + b^2 = c^2 \qquad R = \sqrt{{R_x}^2 + {R_y}^2} \qquad \theta = \tan^{-1}\left(\frac{R_y}{R_x}\right)$$

Projectile Motion:

$$v_{vert\ (initial)} = v_{\text{initial}} \cdot \sin\theta$$

$$\Delta v_{\text{vertical}} = g \cdot t$$

$$v_{\text{vert (final)}} = g \cdot t_{down}$$

$$t_{up} = \frac{v_{\text{vert (initial)}}}{g}$$

$$d_{vertical} = \frac{1}{2}gt^2$$

$$v_{horizontal} = v_{\text{initial}} \cdot \cos\theta$$

$$d_{\text{horizonal}} = v_{\text{horizonal}} \cdot t_{total}$$

$$d_{\text{horizonal}} = \text{range} = \frac{\boldsymbol{v}_{\text{initial}}{}^2 \cdot \sin(2\theta)}{\boldsymbol{g}}$$

$$t_{total} = t_{up} + t_{down}$$

UNIT 4 (FORCES AND NEWTON'S LAWS) EQUATIONS:

$$\boldsymbol{F_{net}} = m \cdot \boldsymbol{a}$$

$$\boldsymbol{F_g} = m \cdot \boldsymbol{g}$$

Vertical Motion:

$$\boldsymbol{F_{up}} = m(\boldsymbol{a} + \boldsymbol{g})$$

$$\boldsymbol{F_{up}} = m(\boldsymbol{g} - \boldsymbol{a})$$

UNIT 5 (DYNAMICS) EQUATIONS:

Momentum and Impulse:

$$\boldsymbol{p} = m \cdot \boldsymbol{v}$$

$$\boldsymbol{Impulse} = \boldsymbol{F} \cdot \Delta t$$

$$\boldsymbol{p_{before}} = \boldsymbol{p'_{after}}$$

$$\boldsymbol{Impulse} = \Delta \boldsymbol{p} = \boldsymbol{p_2} - \boldsymbol{p_1} = m \cdot \Delta \boldsymbol{v}$$

Energy:

$$\boldsymbol{E_K} = \frac{1}{2} m \boldsymbol{v}^2$$

$$\boldsymbol{E_p} = m\boldsymbol{g}h$$

$$\boldsymbol{E_{K1}} + \boldsymbol{E_{P1}} = \boldsymbol{E'_{K2}} + \boldsymbol{E'_{P2}}$$

Work and Power:

$$\boldsymbol{W} = \boldsymbol{F} \cdot d \cdot \cos\theta$$

$$\boldsymbol{P} = \frac{\boldsymbol{W}}{t} = \frac{\Delta \boldsymbol{E}}{t}$$

$$\boldsymbol{W} = \Delta \boldsymbol{E_K} = \boldsymbol{E_{K2}} - \boldsymbol{E_{K1}}$$

$$\boldsymbol{P} = \frac{\boldsymbol{F} \cdot \boldsymbol{d}}{t} = \boldsymbol{F} \cdot \boldsymbol{v}$$

UNIT 6 (WAVES) EQUATIONS:

Mechanical Waves:

$$f = \frac{1}{T}$$

$$v = \frac{\lambda}{T}$$

$$v = f\lambda$$

Sound Waves:

$$v_{sound} = 331 + 0.6T$$

$$dB = 10 \log\left(\frac{I}{I_o}\right)$$

$$\lambda_{observer} = \frac{v_{sound} \pm v_{source}}{f_{source}}$$

$$f_{observer} = \frac{v_{sound}}{v_{sound} \pm v_{source}} f_{source}$$

Standing Waves:

$$L = \frac{n \cdot \lambda}{2}$$

$$L = \frac{\lambda}{2}$$

$$L = \frac{n \cdot \lambda}{4}$$

$$L = \frac{\lambda}{4}$$

Light Waves:

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

UNIT STUDY GUIDES FOR SEMESTER 2 FINAL EXAM:

Unit 5: Dynamics Summary

*** Momentum (p)** → Units: N·s or kg·m/s

$p = m \cdot v$

$p_{before} = p'_{after}$ ↪ Momentum is conserved!

*** Impulse (I or J)** → Units: N·s or kg·m/s

$I = F \cdot \Delta t$

$I = \Delta p = m \cdot \Delta v$

*** Kinetic Energy (E_K)** → Units: Joules (J)

$E_K = \frac{1}{2} m v^2$

*** Gravitational Potential Energy (E_P)** → Units: J

$E_P = mgh = F_g \cdot h$ (mg: "weight!")

*** Mechanical Energy (ME)** → Units: J

$ME = E_K + E_P$

$ME_{Before} = ME'_{after}$ ⇝ Energy is conserved! Cannot be destroyed, only converted to another form of energy!

$E_{K(1)} + E_{P(1)} = E_{K(2)} + E_{P(2)}$

$\Delta E_K = -\Delta E_P$

*** Collisions**

↳ Elastic ("Bouncy")

- E_K is conserved
- p is conserved

$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$

↳ Inelastic ("Sticky")

- E_K is NOT conserved
- p is conserved

$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v'$

*** Work (W)** → Units: J or N·m

$W = F \cdot d \cdot \cos\theta$

if $\theta = 0°$ ⇝ $\cos 0° = 1$!

*** Conservative** vs. **Non-Conservative Forces**

Conservative:

- Independent of path
- $W_{loop} = 0$ N·m
- Examples: Gravity, Spring, Magnetic, Electric

Non-Conservative Forces:

- Depends on the path!
- $W_{loop} \neq 0$ N·m → Change in ME!
- Examples: Friction, Air Resistance

*** Work - Energy Theorem:**

$W = \Delta E$

$W = \Delta E_P = mg(h_2 - h_1)$

$W = \Delta E_K = \frac{1}{2} m (v_2^2 - v_1^2)$

*** Power (P)** → Units: Watts (W)

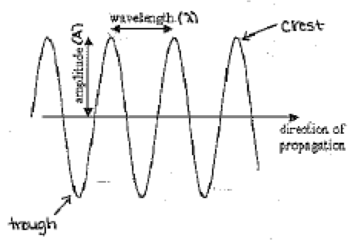
$P = \frac{W}{t} = \frac{\Delta E}{t}$

$P = \frac{F \cdot d}{t} = F \cdot v$

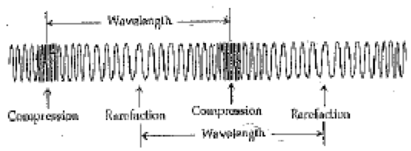
UNIT 6 - WAVES!

* TYPES OF MECHANICAL WAVES:

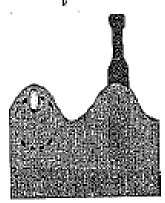
- Transverse Waves: energy transfer perpendicular to particle motion



- Longitudinal Waves: energy transfers parallel to particle motion



- Surface Waves: particles move BOTH parallel and perpendicular to energy transfer. Result is circular motion



* WAVE EQUATIONS:

$$f = \frac{1}{T}$$

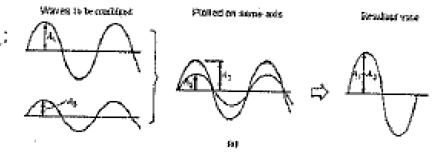
v: wave speed (m/s)
f: frequency (Hz)
λ: wavelength (m)
T: period (s)

$$v = \frac{\lambda}{T}$$

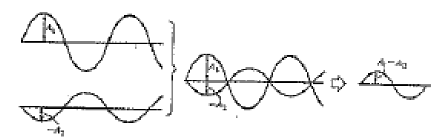
$$v = f\lambda$$

* WAVE BEHAVIOR:

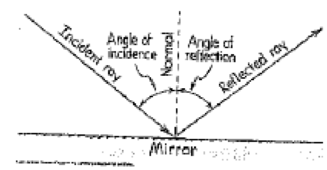
- Interference and Superposition Principle: waves can be in the same place at the same time.
  - Constructive:



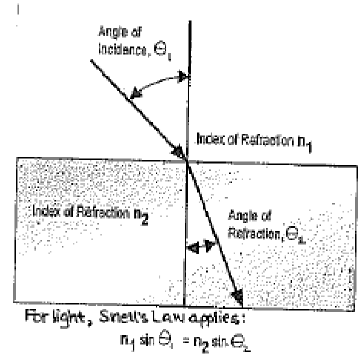
  - Destructive:



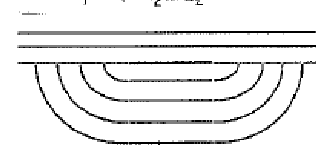
- Law of Reflection: angle of incidence = angle of reflection



- Refraction: Waves bend when they enter a new medium



- Diffraction: waves bend around barriers; circular pattern



* SOUND WAVES:

- Longitudinal waves that need a medium to travel
- Speed of Sound = 343 m/s, but depends on air temperature:

$$v_{\text{sound (air)}} = 331 + 0.6\, T_{\text{air}\,(°C)}$$

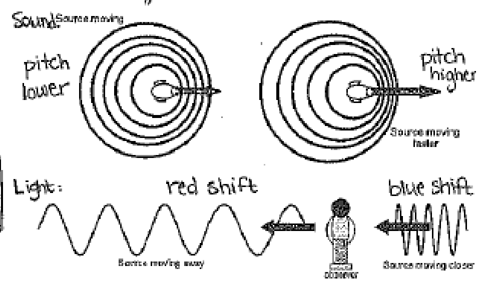
- Sound Intensity: *measured in decibels (dB)*

$$dB = 10 \log\left(\frac{I}{I_o}\right) \qquad I_o = 1 \times 10^{-12}\ W/m^2$$

- Range of Hearing: 20 Hz – 20,000 Hz (20 kHz)
  - Infrasonic frequencies: *lower than 20 Hz*
  - Ultrasonic frequencies: *higher than 20 kHz*
- Doppler Effect:

$$\lambda_{observer} = \frac{V_{sound} \pm V_{source}}{f_{source}}$$

$$f_{observer} = \frac{V_{sound}}{V_{sound} \pm V_{source}}\, f_{source}$$

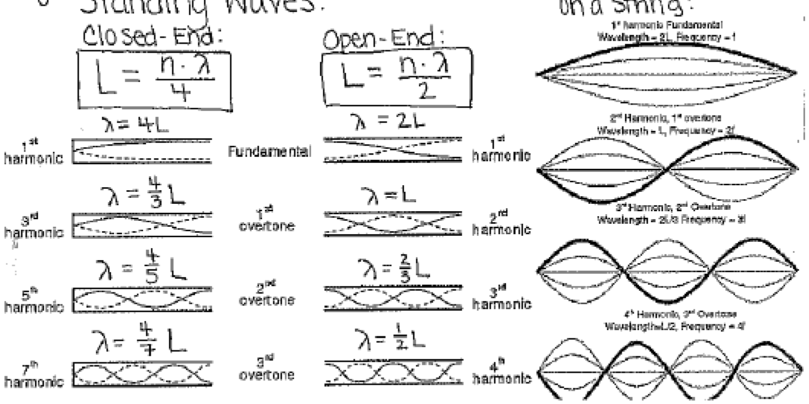


- Standing Waves:

Closed-End: $L = \frac{n \cdot \lambda}{4}$

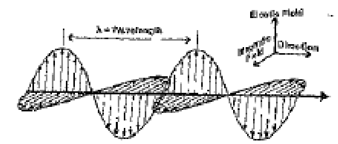
Open-End: $L = \frac{n \cdot \lambda}{2}$

On a String:

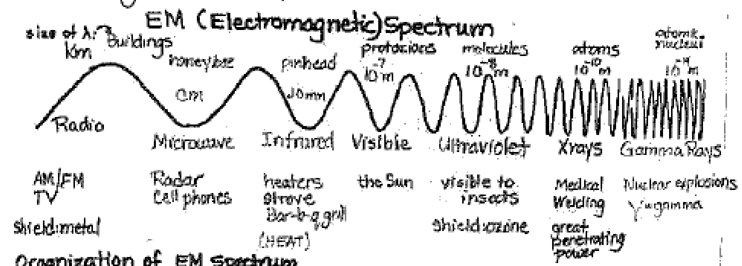


* LIGHT & ELECTROMAGNETIC WAVES

- 2 Dimensional Transverse Wave:
- Speed of Light (c) = 3.00×10^8 m/s



- Electromagnetic (EM) Spectrum:



Organization of EM Spectrum
- λ (wavelength) longest to shortest
- energy low to high
- frequency low to high

f↑ energy↑ λ↑ energy↓

Nuclear Explosions give off Xrays, γ (gamma) rays

Opaque: transmits NO light

Transparent: transmits some light; clear enough to see thru

Translucent: diffuses light so light not clearly distinguished

Shield: something that blocks light

- Color Mixing: