KEY

I

> The motion of an object can be described by measurements of its position at different times. Velocity is a measure of the rate of change of position of an object. Acceleration is a measure of the rate of change of velocity of an object. This change in velocity may be a change in speed and/or direction. Motion is defined relative to the frame of reference from which it is observed. An object's state of motion will remain constant unless unbalanced forces act upon the object. This is Newton's first law of motion.

STANDARD I: Students will understand how to measure, calculate, and describe the motion of an object in terms of position, time, velocity, and acceleration.

1. When scientists study motion, they usually record an objects __position__ at many different __times__ and then they graph it or draw a motion map.

2. Define:

position: x, meters, location measured from reference

rate: two variables change together dollars/banana

distance: full length of path

displacement: how far you are from where you started Δx

speed (write equation too): number only distance/time

velocity (equation too): number and direc[tion] $\Delta x/\Delta t$

average velocity: velocity over a long time interval

instantaneous velocity: velocity at one instant

acceleration (equation too): how quickly velocity changes $\Delta v/\Delta t$

3. Velocity is the change in __position__ divided by the change in __time__.
4. Acceleration is the change in __velocity__ divided by the change in __time__.

5. Name three ways that an object can accelerate. (Three ways that velocity can change.)
speed up
slow down
turn

6. Use the following table of an objects POSITION at given times:

change in position
$y_f - y_i$
slope $= \frac{\Delta y}{\Delta x}$
$x_f - x_i$
change in time

Time (s)	Position (x)
0	25
5	20
10	5

a. Is the object moving towards me or away from me? towards
b. Calculate the velocity of the object in the first 5 s. -1 m/s $= \frac{20-25}{5-0}$ (f − i)
c. Calculate the velocity of the object between 5-10 s. -3 m/s $= \frac{5-20}{10-5}$
d. Is the object accelerating? Explain. yes velocity changed
e. Calculate the AVERAGE velocity for the whole time interval.
$\frac{5-25}{10-0} = \frac{-20}{10} = -2$ m/s

7. Use the following table of an objects VELOCITY at given times:

Time (s)	Velocity (m/s)
0	0
4	8
8	16

slope $= \frac{\Delta y}{\Delta x} = \frac{8-0}{4-0} = 2$ m/s²

a. Is the object speeding up or slowing down? speeding up
b. Calculate the acceleration of the object. 2 m/s²
c. Is there a force acting on this object? Explain.
yes - you can't accelerate without a force

8. Draw a motion map for two cars that are having a race. Car A drives twice as fast as Car B, but car B got a head start. (Be sure to number each dot to show when each object was at that position.)

R

A0 A1 A2 A3 A4 A5

further apart means faster

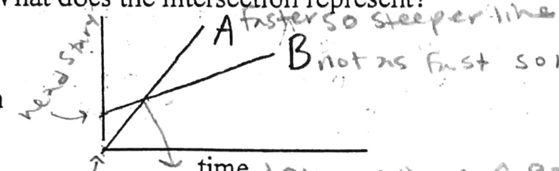
B0 B1 B2 B3 B4 B5

closer together means slower

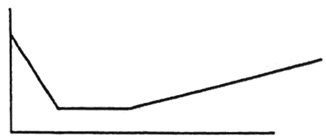
head start

8

9. Draw a POSITION vs time graph for question number ~~2~~ 8. Be sure to show that car A is faster and that car B got a head start. What does the intersection represent?



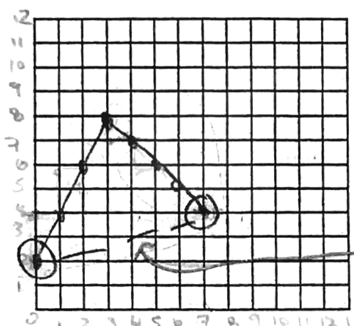
10. Looking at the following position vs time graph, describe the motion of the object using words like towards, away from, fast, and slow.

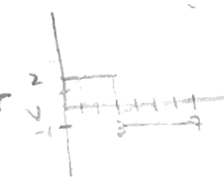


started far away
moved quickly toward reference
stopped
moved slowly away from reference

11. Graph the following POSITION vs time graph.

Position (m)	time (s)
2	0
4	1
6	2
8	3
7	4
6	5
5	6
4	7



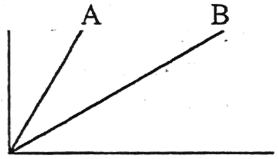


a. Calculate the INSTANTANEOUS velocity in each region. 2 m/s, −1 m/s

b. Calculate the AVERAGE velocity for the whole graph. $\frac{2}{7}$

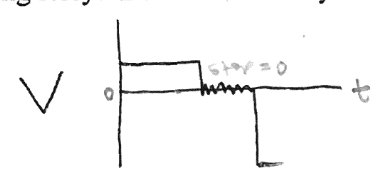
$v = \frac{\Delta x}{\Delta t} = \frac{2}{7} = 0.286$ m/s

12. Which of the following cars is driving fastest? How do you know?

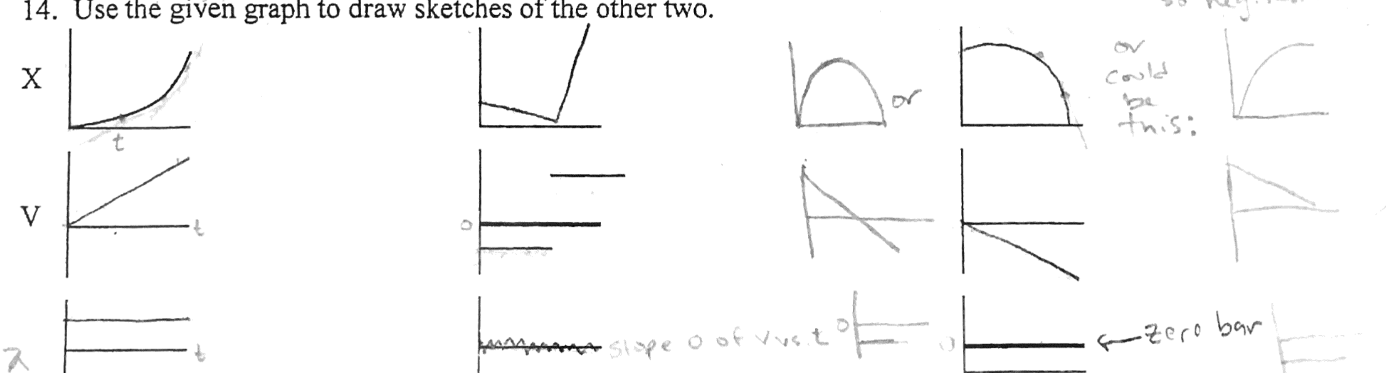


A is steeper

13. Draw a VELOCITY vs time graph for the following story: Bob walked really slow to the store. Then he stopped to rest. Finally, he ran quickly home.



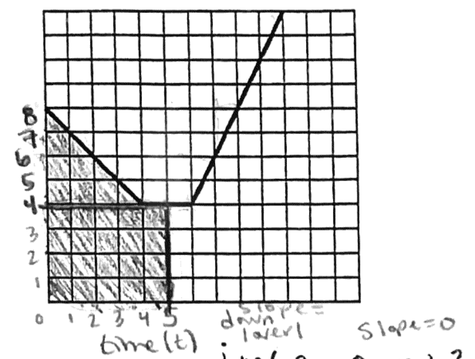
14. Use the given graph to draw sketches of the other two.



15. If the acceleration of an object is zero (the object is NOT accelerating), then I know that the object is either not moving or else it is $a\neq 0$ constant velocity. What is the net (total) force acting on this object? Explain. $\Sigma F = 0$ $a=0$ $F=ma=m(0)$

16. Use the following VELOCITY vs time graph to answer the question.

Velocity (m/s)



Calculate the acceleration for each interval. $-1\ m/s^2$, $0\ m/s^2$, $2\ m/s^2$

Calculate the total displacement between 0 and 5 seconds.

$\triangle = \frac{1}{2}bh = \frac{1}{2}(4)(4) = 8$ $\square = bh = (5)(4) = 20$ $20+8$ area = 28 meters

17. A racecar driver is taking a warm up lap around his circular track. He is careful to keep his speedometer at exactly 85 mph. Is the car accelerating? How do you know? If he is accelerating, what direction is it? Yes, turning, towards the center

18. If acceleration points in the same direction as velocity, then the object will speed up.
If acceleration points in the opposite direction as velocity, then the object will slow down
If acceleration is perpendicular to velocity, then the object will turn.

19. What is a frame of reference? point of view
(what you compare your results with)

20. Bob and Betty are playing tag. Bob is running 5 m/s from my point of view. Meanwhile, Betty is trying to catch him. She is running 7 m/s (straight at him from behind). From BOB's point of view, how fast is Betty moving? Who is right, me or Bob? 2 m/s, both

2 objects w/ own v so vector subtraction

Bob 5 m/s 2 m/s
7 m/s Betty

1. Draw Dot
2. Draw Both vectors from ...
3. Connect observer to observed

21. Car A is driving 50 mph northward. Car B is driving 75 mph southward. Driver A looks out his windshield at driver B. How fast is driver B approaching driver A? (Scary!)

car A 50mph
car B 75mph

$50+75=125$ mph
2 objects w/ own v so vector subtraction
125 mph

22. While driving down the freeway, I drop an apple core out of my window. From MY point of view what does the apple do? (Ignore air resistance.) Draw an arrow. Meanwhile, a highway trooper is parked on the side of the road. What path does the apple take from his point of view? Draw an arrow. Who is right?

You see: ↓ falls down

Trooper sees: falls down and forward

both are right

23. What is Newton's First Law?

Law of Inertia: object in motion stays ---
object at rest stays --- $\boxed{\text{UNLESS}}$ force

24. What is inertia? How do we measure it?

ability to resist acceleration

mass

25. A box is sitting motionless on the floor. At the same instant, Bob and Betty both push on the box with 75 N of force, but in opposite directions. What will the box do? Why?

nothing, balanced forces

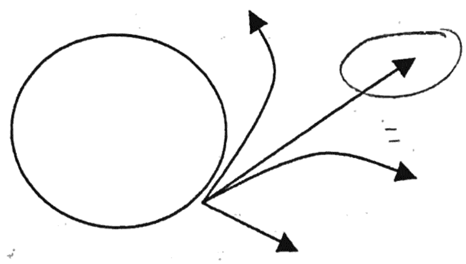
26. Bob is pushing a box across a flat surface. The box is moving at a constant velocity. Who is pushing harder, Bob or friction? How do you know? Same, no acceleration

27. A hockey puck is sliding across a FRICTIONLESS ice rink. What path with the puck follow? How long will it keep moving? straight line forever

28. A child is thrown off of a moving Merry-Go-Round. Which of the following paths will his body take? Why?

inertia goes straight

TOP VIEW LOOKING DOWN



29. In Arches National Park you notice a boulder balanced on top of a narrow rock spike. What forces are acting on the boulder? How do the forces compare to each other? How do you know?

gravity, normal, equal, no acceleration

30. What do we call a system of forces that cancel each other out perfectly? equilibrium

31. A car is driving down the freeway going a steady 60 mph. What do I know about the sum of the forces acting on my car? Why? Name some of the forces acting on my car.

$\Sigma F = 0$ no acceleration gravity = normal

friction = engine

II

Objects in the universe interact with one another by way of forces. Changes in the motion of an object are proportional to the sum of the forces, and inversely proportional to the mass. If one object exerts a force on a second object, the second object always exerts an equal and opposite force on the first object. Whenever a force is applied to an object there is an equal and opposite reaction force.

STANDARD II: Students will understand the relation between force, mass, and acceleration.

1. What do we call any push or pull between objects? force

2. Write the equation for Newton's Second Law of Motion. Use the law to derive an equation for weight (the force of gravity.) $F=ma$ $W=mg$

3. The harder you push something the faster it goes. We say that force and acceleration are directly proportional.

4. If you double the pushing force, then acceleration doubles.

5. The more mass something has the slower it goes. We say that mass and acceleration are inversely proportional.

6. If you double the mass of an object, then acceleration one half.

7. If more than one force is acting on the object, what do you do? find the total force or the Net force ΣF

8. Draw force diagrams for the following situations. Be sure to label each force and show how long the arrows are compared to each other.

a. a rain drop falling from the sky w

b. a bungee jumper hanging from his cord T w

c. a car parked on a hill n f opposes slipping w

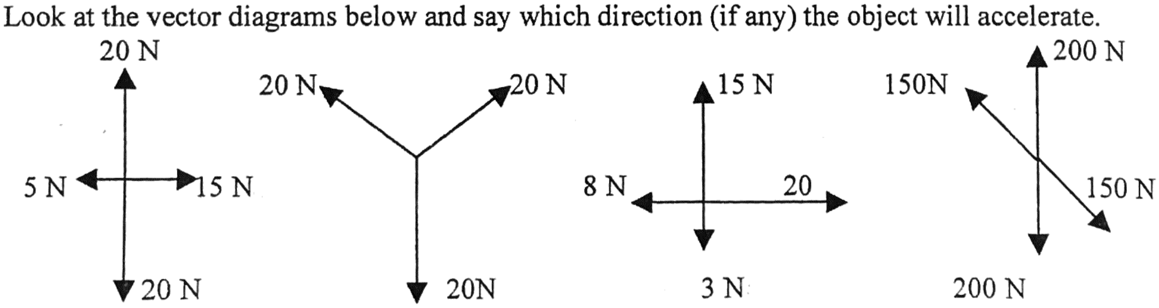
d. a paper clip getting pulled up by a magnet F_{mag} w

e. a box being pushed across the floor at CONSTANT velocity. n f F w

f. a box being pushed across the floor and ACCELERATING n f w F

g. a car slamming on its brakes n f w

9. Look at the vector diagrams below and say which direction (if any) the object will accelerate.



right

none (all Balanced)

up and right

none (Balanced)

10. Bob pushes a 10 kg box forward. It accelerates 0.5 m/s ^{2}. What is the net force acting on the box?

m   a

m $F = ma$ $F = (10)(.5) = 5N$

11. Betty pushes with 50 N of force on a 5 kg object (ignore friction). How fast with the object accelerate?

F   m

$F = ma$ $\frac{F}{m} = a$ $\frac{50}{5} = 10\ m/s^2$

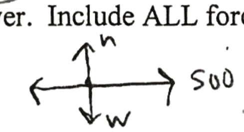
12. Billy pushes an unknown object with 100 N of force. It accelerates 5 m/s ^{2}. How much mass does the object have? (ignore friction)

a

$F = ma$ $m = \frac{F}{a} = \frac{100}{5} = 20\ kg$

13. Belinda pushes a lawnmower forward with 500 N of force. Meanwhile, friction resists her with 200 N of force. Draw a force diagram for the lawn mower. Include ALL forces acting on it. If the lawnmower is 35 kg, how much will it accelerate?

F   f   m



$\Sigma F_x = 500 - 200 = ma$

$a = \frac{500 - 200}{35} \frac{m}{m} = \boxed{8.57\ m/s^2}$

14. What do we use to measure forces? How does it work?

mir Newton   Spring Scale (Newton Meter), uses a spring

15. What is Newton's Third Law of Motion?   action reaction

16. If all forces are equal and opposite, why don't they just cancel each other out? Why does one object often move/break while the other object appears unaffected?   act on different objects,

one object can handle it or has more inertia

17. Identify the size and direction of the pair force.

a. Bob pushes the wall forward with 25 N of force. (The wall ....) pushes Bob backward 25 N.

b. The earth pulls a sky diver down with 150 lbs of force.   Diver pulls earth up 150 lbs.

c. A gun shoots a bullet forward with 1000 N of force.   Bullet shoots gun backward 1000 N.

18. Say how Newton's Third Law is involved in the following activities. Then come up with three more activities of your own.

Equal   opposite   Equal   opposite   3rd Law

a. The rock climber's foot pushes down on the sandstone. The sandstone pushes climber up.
b. Walking. My foot pushes the floor backwards. The floor pushes me forward
c. The rocket pushes the air out backwards. The air pushes rocket forward.

Equal & opposite Forces

Vary
d. Bob Kicks a Soccer ball to the Right, the Soccer ball kicks Bob to the Left
e. Magnet Pulls up on A paper clip. The Paper Clip pulls down on the Magnet.
f. Bob pushes a domino Forward. The domino pushes Bob's hand backward

19. A bicycle gets in a head on collision with a semi truck. During the collision, which pushed harder. The bike on the truck, or the truck on the bike? How do you know? Why does the bike get destroyed, but the truck is fine?   Same,   3rd Law,   Can't handle it

20. Newton was not the first scientist to study the world and develop laws of motion. Name three other scientists that contributed to our understanding of the world around us (even if they weren't always right.)

Aristotle, Galileo, Copernicus

Philosopher   et

VOCABULARY: Define the following

Net Force: total force   Vector Diagram: arrow picture   Weight: force of gravity N

$W = mg$

Vector: arrow   Mass: stuff in an object Kg   Normal Force: force between solid objects

number with direction

III

> Any two objects in the universe with mass exert equal and opposite gravitational forces on one another. The electromagnetic force is manifested as an electric force, a magnetic force, or a combination. Any two objects in the universe with a net electric charge exert equal and opposite electric forces on one another. While gravitational forces are always attractive, electromagnetic forces can be either attractive or repulsive.

STANDARD III: Students will understand the factors determining the strength of gravitational and electric forces.

1. Newton developed the Law of Universal Gravitation which states that every object in the universe has gravity.

2. Bob weighs 800 N. That means the earth pulls down on Bob with 800 N of force. How hard does Bob pull up on the earth? How do we know? Why doesn't the earth move?
800 N   3rd Law   inertia

3. A sky diver is falling down towards the earth because of the force of gravity. At the same time, the earth is falling up. (Why don't we ever notice this?)

4. Electricity is related to magnetism. Both of them can be used to cause the other.

5. How many charges exist in our universe? What are they? Which ones attract? Which ones repel? same   2   (+) (−)   opposites

6. Gravity field lines always point inward. This means that gravity always attract. (attracts or repels)
always pull

7. How are gravity and the electrostatic force similar? How are they different? Diff: strength, distance job
Same: field, fundamental, r^2

8. Write the equation for universal gravitation. What does each letter stand for?

G = gravitational constant
M_1 = mass 1
M_2 = mass 2
r = radius or distance

$$F_g = \frac{G M_1 M_2}{r^2}$$

9. What are the only two factors that influence the strength of gravity? mass distance

10. Write Coloumb's Equation for electrostatic forces. What does each letter stand for?

K = Coloumb's Constant
q_1 = charge 1
q_2 = charge 2
r = radius or distance

$$F_e = \frac{k q_1 q_2}{r^2}$$

11. What are the only two factors that influence the strength of the electrostatic force? charge distance

12. If the distance between two objects DOUBLES, then the strength of the field force 1/4. because inversely proportional squared

13. If the mass of one object DOUBLES, then the strength of gravity doubles.
directly proportional

14. If the charge of BOTH objects DOUBLES, then the strength of the electric force 4X.

15. If the distance between two objects is cut in half, the strength of gravity 4X.

16. What is the difference between MASS and WEIGHT?
stuff in an object force of Gravity

17. How do convert MASS into WEIGHT on planet earth? x9.8
W = mg

18. Bob weighs 220 N. How much MASS does he have? 22 kg
220/9.8

19. Betty has 65 kg of mass. How much does she weigh? 637 N
65(9.8)

20. Betty has 65 kg of mass. She goes to the moon. How much mass does she have now?
65 kg

21. Bob weighs 220 N on earth. He goes to the moon. The moon has 1/6 the gravity of earth. How much does Bob weight now? 37 N
220/6

22. Gravity is an invisible force, so how are we able to study it? effects

23. The sun is HUGE. So why don't we get sucked in by its gravity? distene

24. Why don't we get sucked in by the gravity of big animals like elephants? not enough mass

VOCABULARY

electric force: force between charged particles, push or pull

electric charge: positive or negative

gravitational force: force between objects with mass, always pulls

mass: stuff

weight: how hard gravity pulls

The total energy of the universe is constant; however, the total amount of energy available for useful transformation is almost always decreasing. Energy can be converted from one form to another and move from one system to another. Transformation of energy usually produces heat that spreads to cooler places by radiation, convection, or conduction. Energy can be classified as potential or kinetic energy. Potential energy is stored energy and includes chemical, gravitational, electrostatic, elastic, and nuclear. Kinetic energy is the energy of motion.

STANDARD IV: Students will understand transfer and conservation of energy.

1. What is energy? ability to change things What unit do we use to measure it? Joules When the universe was made it had a certain amount of energy. How much of that energy is still left? (All, Most, Some, A little, None) Explain. Conservation of Energy. It cannot be created or destroyed

2. What does it mean to CONVERT energy? change it from one form to another
What does it mean to TRANSFER energy? move it from one location to another
What happens to the TOTAL amount of energy when we convert it or transfer it? still there b-
What happens to the amount of USEFUL energy when we convert or transfer it? We lose some useful energy
Where does the "missing" energy go? heat and chaos (entropy)

3. List 5 different forms of energy. thermal solar gravitational wind chemical electric elastic Kinetic

4. A common form of energy is HEAT. List (and describe) the three ways that heat can be transferred. Conduction → passed from atom to atom in a chain
Convection → an energetic atom moves to a new location and takes its energy with it
radiation → beamed directly with EM wave

5. Heat is always transferred from __hot__ towards __cold__. Your mom gets mad at you for leaving the freezer open too long and "letting all the cold out." Is this really what is happening? Explain. Actually all the heat in the room is rushing in

6. List AND DESCRIBE 5 types of potential energy.
gravity → potential to fall
elastic → potential to change shapes
chemical → potential to burn or explode
nuclear → potential to release strong force
thermal → heat

7. What is the equation for gravitational potential energy? What does each letter stand for? Bob is 50 kg. He stands on top of his 10 m house. How much gravitational potential energy does Bob have?

$U_g = mgh$ m = mass, g = gravity, h = height

$(50)(9.8)(10) = 4900$ J

8. What is the equation for elastic (spring) potential energy? What does each letter stand for? Bob shoots a bow and arrow. He pulls the string back 0.3 meters. The bow has a spring constant of 250 N/m. How much elastic potential energy does the arrow have before he launches it?

$U_e = \frac{1}{2}kx^2$ K = spring constant, X = stretch distance

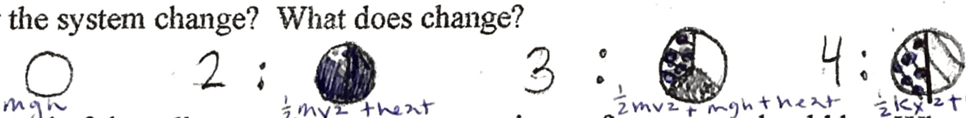
$\frac{1}{2}(250)(0.3)^2 = 11.25$ J

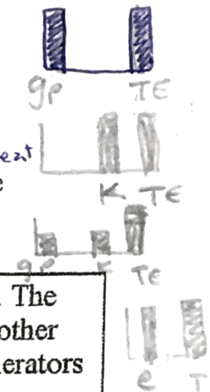
9. What is kinetic energy? What is the equation for kinetic energy? What does each letter stand for? A 1200 kg car is driving 12 m/s down a road. How much kinetic energy does it have?

Energy of motion $K = \frac{1}{2}mv^2$ m = mass v = velocity $\frac{1}{2}(1200)(12)^2 = 86400$ J

10. Draw energy pie charts for the following ~~roller coaster ride~~ ~~bungee jumper~~ roller coaster. Does the TOTAL energy for the system change? What does change?

1 : 2 : 3 : 4 :





11. At the end of the roller coaster, you are not going as fast as you should be. Where did the "missing" energy go? turned into heat

Moving electric charges produce magnetic forces and moving magnets produce electric forces. The interplay of electric and magnetic forces is the basis for electric motors, generators, and many other modern technologies, including the production of electromagnetic waves. Modern electric generators produce electricity by converting mechanical energy into electrical energy.

12. Describe IN DETAIL all the energy transformations involved in using coal to produce electricity. How does that electricity get to my house?

sun → plants → coal → heat → steam → turns turbine blade → turns wire coil in large magnet - makes electricity

13. Moving CHARGES produce magnetic fields. (We can use electricity to make fake magnets. Cool, huh? We call them "electromagnets" and they are a lot stronger than most regular magnets. Junk yards use them to lift cars.)

14. Moving MAGNETS produce electric fields.

15. Machines that MAKE electricity from moving magnets are called generators. Machines that USE electricity to make objects move are called motors.

16. Electricity and magnetism have so much in common that we use one word to describe them both. What is that word?

electromagnetism

KEY

V

Sound and light transfer energy from one location to another as waves. Characteristics of waves include wavelength, amplitude, and frequency. Waves can combine with one another, bend around corners, reflect off surfaces, be absorbed by materials they enter, and change direction when entering a new material. All these effects vary with wavelength. Observable waves include mechanical and electromagnetic waves. Mechanical waves transport energy through a medium. Electromagnetic radiation is differentiated by wavelength or frequency, and includes radio waves, microwaves, infrared, visible light, ultraviolet radiation, x-rays, and gamma rays. These wavelengths vary from radio waves (the longest) to gamma rays (the shortest). In empty space all electromagnetic waves move at the same speed, the "speed of light."

STANDARD V: Students will understand the properties and applications of waves.

1. Waves NEVER transport Objects. Instead, they are used to transport Energy. What do we call the substance that the wave moves through? (for example: ocean waves move through water, sound waves move through air, slinky waves move through slinkies) Medium

2. Define the following:

   a. Wavelength the distance between crests (or troughs
   b. period time between waves $\left(\frac{\text{seconds}}{\text{wave}}\right)$ $T = \frac{1}{f}$
   c. amplitude the height of a wave (measured from the midline)
   d. frequency the # of waves every second $\left(\frac{\text{waves}}{\text{second}}\right)$ $f = \frac{1}{T}$
   e. reflection wave bounces back to original medium
      (what is special about reflection angles) They equal eachother $\theta_1 = \theta_2$
   f. transmission A wave enters a new material & keeps going
   g. diffusion waves spread out in every Direction
   h. refraction wave enters a new material & turns
   i. diffraction 2 slits create multiple stripes

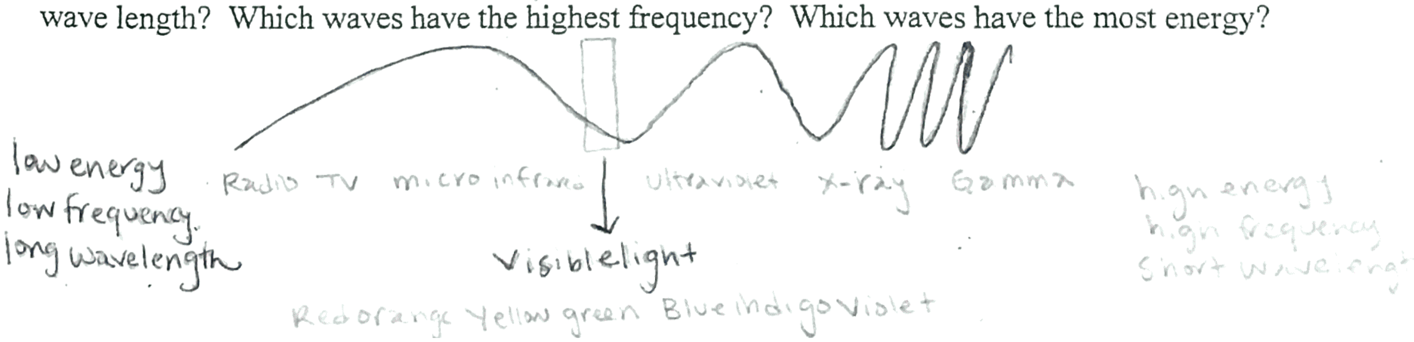
3. Do radio waves, sound waves, light waves, and X-rays all reflect off the same materials or transmit through the same materials? Give examples. What makes these waves all different from each other? No. Electromagnetic waves Don't need a medium to travel through. X-rays go through flesh but not bones & radio waves don't travel through flesh. Wavelength gives the wave Personality → (color, note). Sound needs a medium to travel through light Doesn't

4. What do we call physical waves that you can actually see and touch? What do we call the invisible waves like radio waves and microwaves?

Physical: Mechanical Waves

Invisible: electromagnetic waves

5. Draw a picture of the electromagnetic spectrum, beginning with the longest waves and ending with the shortest waves. Label the order the waves come in: Which waves have the longest wave length? Which waves have the highest frequency? Which waves have the most energy?



6. Big wavelengths have less (more/less) energy than short wavelengths.
High frequencies have more energy than low frequencies.
High amplitudes have more energy than low amplitudes.

7. Which waves travel the fastest: radio, X-ray, light, or gamma rays? (Hint: How fast do each of these waves travel?) They all travel @ the same speed, the speed of light (c) = 3×10^8 m/s

8. Which color has the longest waves? Red
Which color has the highest frequency? Violet
Which color has the least energy? Red

9. When an object is moving towards you, it will sound higher (higher/lower) than usual because Doppler effect: waves are compressed. When an object is moving away from you, it will sound lower (higher/lower) than usual because waves are stretched. We call this the Doppler effect.

10. When a star moves towards planet earth, the colors are all shifted a little bit towards blue because waves are compressed moving towards an object. When a star moves away from planet earth, the colors are all shifted a little bit towards Red because waves are stretched moving away from ob.. Most stars are shifted which direction? What theory does this support? Red shift, the big bang → universe is expanding.

11. The amplitude of a sound wave determines its Loudness. (intensity)
The frequency of a sound wave determines its Pitch.
The amplitude of a light wave determines its Brightness. (intensity)
The frequency of a light wave determines its Color.

12. What are the TWO equations for wave velocity? What does each letter stand for? Calculate the velocity of an ocean wave if it has a wavelength of 10 m λ and a frequency of 2 Hz. f Calculate the velocity of a slinky wave if it has a wavelength of 1.5 meters λ and a time period of 0.5 T seconds. $v = \frac{\lambda}{T}$ and $v = \lambda f$ v = velocity, λ = wavelength, T = time period, f = freq

$v = \lambda f = (10)(2) = \boxed{20 m/s}$ $v = \frac{\lambda}{T} = \frac{1.5}{0.5} = \boxed{3 m/s}$

13. List 5 examples of waves that we use in real life. (For example: Cell phones use waves to communicate with satellites.)

- Micro → for microwaves → cooks or heats food.
- TV → Television signals
- X-rays → X-ray pictures
- Radio → radio signals → long range communication
- Infrared → night vision goggles