Physics Syllabus, Grade 9

General objectives of Grade 9 Physics

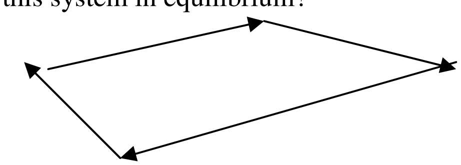
After completing Grade 9 physics lessons students will be able to:

- Understand the basic concepts of physics, the laws of dynamics and explore different kinds of forces, the quantification and forms of energy (mechanical, sound, light, thermal, and), and the way energy is transformed and transmitted, the concepts and units related to energy, work, and power and the laws of conservation of energy and of momentum for objects moving in one dimensions
- Develop manipulative skills in solving problems related to the laws of conservation of momentum and energy
- understand of the properties of mechanical waves and sound and the principles underlying the production, transmission, of mechanical waves and sound; the properties of light and the principles underlying the transmission of light through a medium and from one medium to another;
- Develop scientific-inquiry skills as they verify accepted laws and solve both assigned problems and those emerging from their investigations.
- Analyze the interrelationships between physics and technology, and consider the impact of technological applications of physics on society and the environment.
- solve the problems using a variety of problem-solving skills.

Unit 1: Vectors *(9 periods)*

***Unit outcomes*:** Students will be able to:

- Acquire knowledge and understandings of vector representation, vector addition and subtraction, and properties of vectors
- Develop skills of resolving and composing vectors.
- Develop interest in solving problems using vector approach.

Competencies	***Contents***	***Suggested Activities***
Students will be able to : • Define the term vector. • Represent vectors analytically • Represent vectors graphically • Add two vectors: along the same direction, opposite direction and at right angles to each other. • Specify the direction the resultant vectors using an angle. • Resolve vectors in to rectangular components. • Find the magnitude and direction of the resultant of two or more vectors using component method. • Use $R=\sqrt{(Rx2 + Ry2)}$ to determine the magnitude	***1. Vectors*** **1.1 Representation of vectors** *(2 periods)* • Analytical • Graphical **1.2 Addition and subtraction of vectors.** *(5 periods)* • Graphically • By component methods	You need a review on vectors. Vectors are real but invisible. It should start off this unit. The idea of "reality of the unseen" is important. Students should list all the concepts in physics that are "Unseen" but must be real. Students should be able to add and subtract vectors graphically by the tip to tail method or the parallelogram method. Activity: the teacher makes up several "Mystery paths" that include directions like "East 2m from a starting point. North 4 m, then west 3 m, then south 1 m. Then. East 3 m. Students act out the directions in the problem. When the problem is completed they measure the distance from the starting point. They copy the problem down and do it on graph paper. They measure the distance with a scale of one box = 1 m. Using the theorem of Pythagoras they solve the problem mathematically and compare answers. Problem solving: Let the students solve graphically addition or subtraction of vectors. They should be able to express the resultant using the theorem of Pythagoras interpreted from graph paper. Do lots of Peer Instruction on forces and adding them. It is much more efficient than board work. Sample: Peer instruction: Is this system in equilibrium?  1) yes 2) no Some will complain that the sides are not parallel. The tip to tail brings a sum of zero, so yes. Two force vectors acting on an object can add to zero, making equilibrium. Is it possible for 3 forces to add to a sum of zero?

Competencies	***Contents***	***Suggested Activities***
of the resultant vectors. • Apply tanθ= Ry/ Rx to determine the direction of the resultant vectors. • Find the angle of the resultant vector R makes with respect to the positive x-axis.		1) yes 2) no Explain in groups. $\sum F_x = 0, \sum F_y = 0$ • Use the sigma notation. Invite students to make up their own force vectors in two dimensions that add up to zero. Invite them to put them into the equation with the sigmas. Step one: Three forces in x direction 2 in y Step two: four forces in x direction 3 in y Step Three: forces at 45degrees -45 degrees 135 degrees and -135 degrees all adding to zero. Students must demonstrate the knowledge of component vectors. Peer instruction on equilibrium or non-equilibrium See Mazur for many examples. Put up a vector drawing. Is this system in equilibrium or not? Students vote.
• Use the appropriate sign convention of vector components in the solution of problems • Define the term equilibrium	**1.3 Some applications of vectors** *(2 periods)* • Equilibrium • Experimental approach	

Assessment

The teacher should assess each students work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level

Student working at the minimum requirement level will be able to : define and describe concepts related to vectors, scalars, representation of vectors, addition and subtraction of vectors, condition of equilibrium; apply mathematical concepts such as the Pythagorean Theorem and trigonometric relationships in solving vector problems; resolve a vector into its two independent component vectors; determine the resultant vector of two or more non-perpendicular vectors acting in two dimensions using the vector component method.

Students above minimum requirement level

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level

Students working below the minimum requirement level will require extra help if they are to catch up with rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

Unit 2: Motion in a straight line *(12 periods)*

***Unit outcomes*: Students will be able to:**

- gain knowledge and understanding on uniform and uniformly accelerated motion, and about relative velocity in one dimension
- develop skills in applying equations of uniformly accelerated motion in solving problems
- develop skills in drawing and interpreting graphs representing uniform and uniformly accelerated motion
- appreciate the mathematical and graphical representation of motion
- demonstrate an understanding of different kinds of motion and of the quantitative relationships among displacement, velocity, and acceleration, and solve simple problems involving displacement, velocity, and acceleration;
- design and conduct investigations on the displacement, velocity, and acceleration of an object; analyze everyday phenomena in terms of the motions involved.

Competencies	***Contents***	***Suggested Activities***
Students will be able to: • Explain the terms: distance, displacement, speed, velocity and acceleration. • Explain the difference between distance and displacement. • distinguish among constant, instantaneous, and average speed and among constant, instantaneous, and average velocity, and give examples involving uniform and non uniform motion; • Draw graphs of: S vs t, V vs t, and a vs t graphs using recorded data • Complete the S vs t table, given some initial information.	***2. Motion in a straight line*** **2.1 uniform motion** *(2 periods)* **2.2 uniformly accelerated motion** *(2 periods)*	The teacher should use the Human Measuring Line Data analysis. The key idea is creating the accurate velocity vs time graph. In Previous Units (Grade7 and 8) we just plotted Average Vel versus time. This chapter takes a deeper look. The average Velocity really is the instantaneous velocity at some point. Activity: Model this with a person walking between two points even with a very uneven velocity (including backwards). The only rules are that after 3 seconds the student must be at the endpoint and D=4m. Ask someone to do a qualitative graph at the same time as the walking of vel vs t. It might be quite jagged and non-linear, even crossing the axis to show backwards motion. Do another jagged walk under the same conditions t= 3s and d=4m. The average velocity is calculated from D/T and compared to the qualitative graph. At some point in the time the person MUST have gone at the average velocity, though the instantaneous velocity was constantly changing. What point we don't know, but velocity must be a continuous graph. You cannot instantaneously jump from one place to another. Instantaneous velocity might be immeasurable, but there are ways to calculate it • If the velocity is constantly increasing over an interval (no jagged motions) then the average Velocity must be the instantaneous velocity at the TIME Midpoint. This is a key idea. It fundamentally is the Mean value theorem for linear functions. Use this idea to know V avg as V instant at T MID (mid point) This will give you an excellent way to calculate via a graph, the acceleration Activity: Start out with the Human Measuring line: Do several experiments with different speeds.

Competencies	***Contents***	***Suggested Activities***
• Solve problems using S vs t and V vs t graphs • determine the distance and displacement of a body from graphical representation of motion • Use equation of uniformly accelerated motion to solve problems. • Use the appropriate sign convention of (velocity	**2.3 Graphical description of uniformly accelerated motion**. *(2 periods)* • Freely fall motion	Make Dot Plots. Peer Instruction: What is the Average velocity on a dot plot? Sum of all velocities of the interval/no of intervals How does this compare with the average velocity in each interval? a) Average velocities in each interval are the same as the average for the whole interval b) different from the average velocity for the interval Let the students vote and discuss to arrive at the correct answer Dot Plots for segmented motion: Activity: students make up their own stories about motion: Constraints: they must use velocities of only 2km/s, 4km/s, 6km/s, Or -4km/s or -6km/s or 0 km/s. Graph One: make a vel vs. t graph for their story. Students make the graphs very accurately. Three groups of students' 6-8 each give the teacher their v vs t graphs; then they stand up and give the verbal description of their motion. The rest of the class matches the verbal description with the graphs. Repeat the process. Do the same activity with the constraint that the person must get back home after the travels. Students must calculate how far he went, then go backwards to get home again. TEXT (Note): the text must give the rational for the area under a v vs t plot to be the distance traveled. IDEA: insert some of Newton's reasoning. Let us assume that we look at a very small time interval. Perhaps the velocity is not linearly increasing or decreasing. Students construct a "micro view" peeking into a very small interval of time on a v vs t graph. The argument is that the average velocity in that small time interval times the time interval must be the distance traveled. Larger or smaller velocity values will average out. Distance traveled in $\Delta t = V_{averge} * \Delta t$ If one adds of the $V_{averge} * \Delta t$ segments, this is the area under the Vel vs t diagram. This is the start of the study of calculus. Since vel vs. t is constant for simple motion, distance traveled for constant velocity is simply the sum of a group of rectangles. Some rectangles will have negative areas. Activity: Accelerated motion using the Human Line. Let the students measure a motion that is either accelerating or decelerating. Use a bicycle or a person riding on a board with some wheels. Deceleration is simple: friction will suffice. To accelerate a person on a wheel one must use a weight pulled by gravity. The weight must hang out a window or operate from a pulley from the ceiling (two pulleys are needed as the force must be horizontal). The bicycle is easier to do initially as it accelerates slowly. Rolling a heavy dumbbell from a ramp gives good results. The dumbbell must be relatively

Competencies	***Contents***	***Suggested Activities***
vector, acceleration vector) in the solution of problems		smooth and the path should be about 2-3 meters. For the bicycle and dumbbell you may need to adjust the timer to one second intervals, though 2 second intervals is easier to capture data. Error rates increase with smaller intervals. Students create several Dot Plots of accelerated or decelerated motion. They transfer these to notebooks and then to tables of data. Then they calculate the average velocity for each interval of time. The key idea is that the velocity is changing instantaneously. This immeasurable quantity is called **instantaneous velocity**. In any time interval, the instantaneous velocity must, at some time during the interval, have the same value as the average velocity for that interval. Velocity must be continuously changing, no jumps are permitted, say 2m/s then instantly 2.5 m/s. We make the claim that $V_{average}=V_{instat\ at\ the\ time\ midpoint}$ Students plot the average velocity for the intervals against the time midpoint. This is a very important idea. The v vs. t plot lets us measure something that is immeasurable any other way, $v_{instant}$. This is a continued theme in physics: viewing and measuring the invisible. Students construct V vs t plots for the accelerated motions They find the slope of the lines. There will be some error. They fit a line to their data. It will be more accurate when the object is moving more slowly and less accurate when it is moving quickly.
• Distinguish between uniform and uniformly accelerated motion. • Give examples of uniform and uniformly accelerated motion. • Explain free fall motion. • Use equations of uniformly accelerated motion to solve problems related to free fall	**2.4 Equation of uniformly accelerated motion** *(4 periods)*	Students find the area under the v vs. t graph. It should be the distance traveled. Activity: at this time the instructor gathers all information from the students about what they know about equations of motion. He writes them on the board. He organizes them into the four Galilean equations of motion 1. $D = V_{avg} * \Delta t$ 2. $V_{avg} = (V_{final} + V_{initial})/ 2$ 3. $V_{instantaneous} = a * \Delta t$ (with no starting velocity) 4. $D = V_{initial} * \Delta t + ½ a *(\Delta t)^2$ (with initial speed) 5. $V_{fina}^2 = V_{initial}^2 + 2 a D$ (timeless) If $V_{initial} = 0$ then equation 4 becomes $D = ½ a* t^2$ as we have already seen. Students may attempt to derive equation 5 from the others. Problem solving: As in the previous text students do a lot of problem solving using the 4 Galilean equations.
• Define the term reference point(frame) • Describe the term relative velocity. • Calculate the relative velocity of one body with		Look at $S = ut + 1/2\ at^2$, qualitatively The first term is just motion with constant velocity The acceleration term has a 1/2 in it. Why? PEER INSTRUCTION: Equation #2 has a ½ in it: A) for the same reason that equation #4 has a ½ B) For a very different reason.

Competencies	*Contents*	*Suggested Activities*
respect to the other when moving: in the same direction, and opposite in direction	**2.5 Relative velocity in one dimension** *(2 periods)*	Look at the area under a v vs. t graph with starting at non-zero v. This is the area of a rectangle plus a triangle. Substitution will get the last equation. Students will develop skill in selecting which of the Galilean equations to employ in solving problems. They should exercise skill in applying rules for significant digits in solving these problems. Ask students to carry out calculations on relevant formula. • Guide students in investigating the value of g in their locality using free fall Experiment. Let students produce graphs of uniformly accelerated motion The Human Line has much more available material . This is all fundamentally done in the Human Line segment. Question: Why determine the acceleration of gravity? OK go ahead with it but only for a demo of accuracy and experimental method. Activity: Station two persons at the top and bottom of a high wall, preferably two stories or higher. The person at the top should release a ball and the person at the bottom should measure the time taken to reach the ground. Then use $D=(\frac{1}{2})gt^2$ to determine the value of 'g'. • Use real life experience of the students to explain the relative velocity concept first in the same direction then in the opposite direction Model with: Change the direction of the scale of the Human line. Go Left to right. What does that do to the lines on the graphs? Shift it over 1 m. Add one m and start there. The point is that the data is relative to the instrument. We already know that all position is relative; position depends on the zero point of the ruler. All time is relative; again what is the starting point in time? Students should appreciate that all velocity is relative. It depends on the frame from which you are observing. Students will give examples of frames in which some objects appear to be moving, but are stationary in their own frame. The students should appreciate that all physical equations are valid in either constant velocity moving or non-moving frames. The concept of moving or non-moving is dependent on the observer.

Assessment

The teacher should assess each students work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level

A student working at the minimum requirement level will be able to : define and describe concepts and units related to motion (e.g., vectors, scalars, displacement, uniform motion, instantaneous and average velocity, uniform acceleration, instantaneous and average acceleration); describe and explain different kinds of motion, and apply the quantitatively relationships among displacement, velocity, and acceleration in relevant problems; interpret patterns and trends in data by means of graphs drawn , and infer or calculate linear and non-linear relationships among variables (e.g., analyze and explain the motion of objects using displacement-time graphs, velocity-time graphs, and acceleration-time graphs.)

Students above minimum requirement level

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level

Students working below the minimum requirement level will require extra help if they are to catch up with rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

Unit 3: Force and Newton's Laws of motion *(19 periods)*

***Unit outcomes*: Students will be able to:**

- Gain knowledge and understandings on forces in general ,laws of motion, linear momentum and impulse, conservation of linear momentum, and first condition of equilibrium
- Develop skills in resolving and composing forces ,applying Newton's laws of motion in solving problems, using the law of conservation of linear momentum, drawing free body diagram
- Appreciate the vector nature of force, the application of Newton's laws in daily life activities.

Competencies	***Contents***	***Suggested Activities***
Students will be able to: • List the forces that occur in nature.	***3. Force and Newton's laws of motion*** **3.1 Forces in nature** *(2 periods)* • What are physical forces? • Contact and non contact forces	The teacher invites students to list all the forces they know of: He/she groups the forces by kind as the students offer suggestions. Non-physical forces are placed to one side. It is important to recognize these ideas publicly. These are the misconceptions that are often very hard to overcome: example "the force that keeps an object moving" That does not exist by Newton's first law. Sample physical forces: • gravity • Friction (note the two kinds and that friction is a rather strange force, it only acts against you. You can do work against friction). • Electric and magnetic force • Buoyant force
• State Newton's first law • categorize forces as contact or non contact • Explain the relationship between mass and inertia. • Distinguish between elastic and inelastic materials • State Hooke's law • Read the magnitude of force using spring balance • Express the dimension and SI unit of force constant of a spring.	• Newton's first law	Activity: Bridging metaphor to the First Law. Have a 'V' track 2-3 m long with a shorter "launch" track. The 'V' must be very smooth metal either iron or aluminum laid horizontally on a table or a row of desks. Use a large bearing. Have a stop to halt motion. Roll the ball down a 45 degree ramp with the stop about .5 m from the start. Move the stop to 1m. Observe the velocity. If the track is smooth it should be low friction. Move the stop to 1.5 m then to 2 m. then to the end. Perhaps a slight tilt (unseen) might help. What about the speed of the ball? It is relatively constant. Imagine we had a track infinitely long with no friction? This is an invitation to state Newton's First law Peer Instruction: From a diagram (say a book on a table) students count the number of forces on it. Another diagram: A person pushing a package on a floor with friction. Count the forces. A person pushing a block up a ramp, count the forces. A helicopter hovering over the ground. Count the forces. Note: clarify the effects of forces in real life examples, demonstration/experiments are required to be done by either you or the students.

Competencies	***Contents***	***Suggested Activities***
• Determine the spring constant K of a spring. • Determine the acceleration of a body attached to the spring in a vertical position • Apply Fnet=ma to solve some problems • Distinguish between resultant force and equilibrant force. • Describe the effect of force acting on a body • Resolve forces acting on a body into rectangular components • Compose forces acting on a body using component methods • Describe the weight of a body. • Explain why the weight of a body varies on the surface of the earth. • Distinguish between the weight and apparent weight. • Explain the phenomena of weightlessness. • Calculate the true and apparent weight of a body suspended in a moving elevator	**3.2 Newton's second law** *(2 periods)* • Weight • Weightlessness	• Do free body diagrams for a great many common examples. Include some accelerating motions. • Do sample calculations and ask students to do so. • Demonstrate/experiment to relate F, a, m using practical examples Encourage students to discuss the concept of weight and how it is different from mass. Peer instruction: Diagram. Object 500 km over the earth. Is it weightless? Cards: 1) Yes 2) no It has less weight than at the earth level Diagram. Object exactly between earth and moon? Is it weightless? Cards: 1) Yes 2) no No. The earth pulls more than the moon. Very low weight. Diagram. Object exactly between about ¼ of the way to the moon, ¾ of the way to the earth? Is it weightless? Cards: 1) Yes 2) no Yes. The earth pulls about the same here as the earth is about 4 times the mass of the moon. F=mg still works here but the g is changing. At that special point, the first Lagrangian, Force from Earth= force from moon and g=0. Later explain how it varies with the position on the earth's surface. Using the equation. W = mg ask students to do calculations. List the causes of friction? Invite ideas. 1) Really geometric – very rough surfaces like sandpaper grinding on one another. 2) On smooth surfaces atoms or molecules can attract and cause frictional force. What are the two kinds of friction? Peer Instruction: Why is static friction greater than kinetic friction? 1) Because they make more rough edges with pressure. 2) Because the atoms or molecules press tight and may have some bonding. Peer Instruction: Why does adding oil or grease to a surface make sliding easier 1) because oil makes things slide 2) Because oil is a round molecule and it acts like a ball bearing. #1 is a tautology. Why does grease make things slide? Class response by groups after 1 minute discussion. It is more solid than oil and smoothes out the bumps. Tell students that in the previous lessons frictional force is assumed to be negligible. But in real life friction force is not zero. • Do demonstration to distinguish between static and kinetic friction.

Competencies	***Contents***	***Suggested Activities***
• Explain how frictional force depends on the nature of surfaces and the normal contact force. • Describe the differences among the terms: Limiting friction, static friction, kinetic friction. • Draw a free body diagram representing all the force components acting on the body moving along the inclined plane. • Use free body diagrams representing forces on a body to solve problems • State Newton's third law • Give examples where Newton's third law is applicable • Demonstrate Newton's third law using inflated balloon. • Define the term linear momentum	**3.3 Frictional force** *(3 periods)* • Kinds of friction • Calculating friction and normal force **3.4 Newton's third law** *(4 periods)* • Linear momentum	• Using the equation f = μN do sample questions. Calculate μ_{static} for a table or desk. Do the same for the same block on rough sandpaper. Calculate $\mu_{kinetic}$ for a table or desk. Using the same block. Put some oil or grease on the sandpaper: make a prediction. Calculate μ_{static} with oil on the sandpaper Let students say something about how they have played with cart made from wood and ball bearing, Ask students to give real life examples of action and reaction. Make a list on the board. Which is the action, which is the reaction? Have students make drawings. If there is motion have the student show which force causes the motion. Remember with a bike on the road it is the ROAD pushing back that causes the motion. Define Free body diagram. For each of the student suggestions the teacher draws a free body diagram on the forces. FBDs(Free body diagrams) help focus the mind on the physics of a situation. Invite more student suggestions. Invite a student to draw an FBD around the situations. Peer Instruction: The instructor puts up some drawings with forces on them. Some are correct some are wrong. Is this a correct FBD? 1) Yes 2) No Activity: Two students on chairs oppose each other and push with their legs on the chairs. What are the forces on the system? Invite students to tell. Make a diagram. Be clear about what force is on what object. Increase the force until one move. Why does the lighter one move? Is the force less? Double the weight of the light one with 2 students. Do it again. Redraw the diagrams. Invite students to give ideas of what "Momentum" means to them. Separate out non-physics usages: political momentum, momentum in a soccer game for a team. Important: "the force behind a moving object that keeps it moving" this is a false idea. It is called "impetus"; people thought that the thrower gave a "motion force" to an object that kept it going. Newton gave a much better scientific idea. Define the concept of momentum. It is a vector quantity $\vec{P} = m\vec{V}$

Competencies	*Contents*	*Suggested Activities*
• Express the dimension and unit of momentum • Solve numerical problems using the definition of momentum • State Newton's second law in terms of the rate of change of momentum		Activity: Qualitative sense of momentum: Class work: Which has more momentum? A 2 kg ball moving at 1 m/s or a 2kg ball moving at 2m/s? One thinks about having a collision with some clay. Which makes a bigger dent? That one has more momentum. A 2kg ball moving at 2m/s or a 4 kg ball moving at 1m/sec? Explain the answer. Peer Instruction: Objects have momentum out in space: 1) yes 2) no Discussion. Momentum is defined on mass, not weight. Objects out in space, even in places with no gravity, will have momentum. Important point, just like mass, momentum is one of the important universal properties of matter. It is not an obvious one, however Ever been hit hard by a soccer ball? Mass of a soccer ball = 300gm Speed of a 50kg soccer player= 5 km/hour. How fast must a soccer ball be going for the goalie to feel like he has been hit by a person? Is that a reasonable speed for a kicker to attain in a soccer kick? Do some calculations. How long does a powerful kick from a goalie stay in the air? How far does it go? Calculate a max speed of a kick. Do another calculation: Knowing the speed of a very fast soccer ball, what speed must a 50Kg soccer player have to attain the same momentum. Is this fast or slow? What can you say about the speed of a 60 kg soccer player? What speed would he have to go to have that momentum? Solve simple examples on momentum • Give an exercise on momentum for the students in the class. Equal momentum, unequal momentum. • No conservation yet. Solve simple examples on impulse and momentum • Give an exercise on impulse and momentum for the students in the class .Impulse has a very specific meaning in physics. It does not mean anything like a mental idea or a will or a wish. • Force is what changes an object's velocity. Newton's laws tell us that a change in velocity from V_1 to V_2 which happened from the action of the force F.

Competencies	***Contents***	***Suggested Activities***
• State the law of conservation of linear momentum. • Use the law of conservation of linear momentum to solve related problems • Express the dimension and unit of impulse. • Describe the relation between impulse and change in momentum • Solve problems using impulse-momentum relation	• Impulse and momentum **3.5 Conservation of linear momentum***(3 periods)*	$m\vec{V}_2 - m\vec{V}_1 = \Delta\vec{P}$ But that change in momentum is caused by a force acting over time. Consider the units Force x time = (Nt m/sec^2) time = Nt m/sec This is the same units as momentum. Relation between momentum and impulse: $m\vec{V}_2 - m\vec{V}_1 = \Delta\vec{P} = \vec{F}orce \times time$ This simple equation will give very surprising results. examples on impulse and momentum • Give an exercise on impulse and momentum for the students in the class With the definition of momentum coming from Newton's Universal laws, there is a new Conservation Law - the Conservation of Momentum. It is universal, applying from atoms to galaxies. One cannot lose or gain momentum under any condition. $\vec{P}_{initial} = \vec{P}_{final}$ $\sum \vec{P}_{initial} = \sum \vec{P}_{final}$ This equation applies in individual cases as well as across the whole universe. Momentum is conserved in all collisions. At first we will consider some kinds of inelastic collisions – one in which the two objects meet and form one after the collision. Do some examples of inelastic collisions. A 30kg soccer goalie jumps up vertically. He catches a 300gm soccer ball going at 8 km/sec. The two move backwards, at what speed? A 5 g bullet traveling at 1 Km /sec hits a 2 Kg log on a frictionless surface. It embeds itself in the wood. At What speed does the two move and in what direction? What would happen if the mass of the bullet were 10 gm? A rocket in space turns on its motors for 3 sec. The 1,000 kg rocket is at rest at first. The force of its motor is 2,000 Nt. What is its final speed? That same rocket puts a steel rope onto a 200 kg satellite which is at rest after the motor stops. What speed to the coupled masses now move with? Let the students do simple one dimensional conservation of momentum problems (totally inelastic collisions) and impulse problem without friction. Instructor works the problem on the board: Surprising calculation: Measuring the unseen. Consider the 5g bullet again: It is traveling at 1 Km /sec hits a 2 Kg log on a frictionless surface. It embeds itself in the wood 3 cm deep. What is the average force the bullet exerts on

Competencies	***Contents***	***Suggested Activities***
		the log? It sounds impossible to do but the impulse Equation will let you do it. The bullet went from 1 km/sec to about zero km/sec. Its average speed was .5 km/sec. $D=V_{avg}t$. So 2cm =.002km = $V_{avg}t$ but we know V_{avg}=.5km/sec. So t=.002km/.5km/sec = .004sec. That is the time it takes the bullet to enter the wood and stop. But the impulse equation says $F\Delta t = \Delta(mV)$ $\Delta(mv) = m(V_f-V_i)$=.005kg(about 0km/sec-1km/sec) so F(.002 sec) = Δ(mV)=-5kg km/sec F = (-5kg km/sec)/(.004sec) F=1,250 Kg km/sec^2 But 1 Nt = kg m/ sec^2 The F on bullet to stop it must be: F=1,250 kg km/ sec^2 x 1000 m/km = 1,250,000Nt The result is surprising but it follows from the fundamental laws of physics. Applications include designing bullet proof vests or deflectors of bullets. It is surprising how powerful these forces can be.
• Distinguish between elastic and inelastic collision	**3.6 Collision** *(2 periods)* • Elastic Collision Inelastic Collision	Do some additional impulse equations in one dimension with no friction with totally inelastic collisions. Elastic collisions are more complicated to calculate. We will do some examples of simple elastic collisions. In an elastic collision kinetic energy is conserved. We will calculate only using vector momentum. Sample on the board. In a serve 650 g tennis racket strikes a ball going 2 km/sec. The tennis ball has a mass of 67 g. After the collision the speed of the racket is 1.8 km/sec. How fast did the ball leave the racket?
• Apply the first condition of equilibrium to solve related problems. • state the condition for linear equilibrium • judge whether a given system is in equilibrium or not	**3.7 The first condition of equilibrium** *(3 periods)*	Special fast camera shows that the time of interaction with the ball and the racket is .001 sec. What was the average force on the ball? These are more difficult problems. Students should do simple elastic collisions in which only one variable, the mass of the object bouncing off is unknown. Soccer examples are good Motion/impulse Jeopardy this reviews all the terms and calculations of the unit. Card: Nt m/s Answer what is momentum. 5 Nt 2 sec Answer with is an impulse of 5 Nt applied over 2 seconds. Or what is an impulse of 20 Nt sec Or $(m V_f-mV_i)$ Answer what is an impulse or change in momentum. Or some simple numerical problems with conservation of energy where one term has a question mark in it

Assessment

The teacher should assess each students work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level

A student working at the minimum requirement level will be able to : define and describe concepts and units related to force and motion (e.g., vectors, applied force, net force, static friction, kinetic friction, coefficients of friction); identify and describe the fundamental forces of nature; analyze and describe the gravitational force acting on an object near the surface of the Earth; analyze and describe the forces acting on an object, using free-body diagrams, and determine the acceleration of the object; state Newton's laws, and apply them to explain the motion of objects in a variety of contexts; analyze in qualitative terms, using Newton's laws, the relationships among the net force acting on an object, its mass, and its acceleration; analyze and explain the relationship between an understanding of forces and motion; use vectors, trigonometry, and the resolution of vectors into perpendicular components, to determine the net force acting on an object and its resulting motion; define and describe the concepts and units related to momentum, impulse.

Students above minimum requirement level

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level

Students working below the minimum requirement level will require extra help if they are to catch up with rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

Unit 4: Work, Energy, and Power *(11 periods)*

Unit outcomes: Students will be able to:

- Develop knowledge and understanding of mechanical work, energy, and power
- Acquire knowledge and understanding on collision in one dimension
- Develop skills in computing the work done by a force, applying work-energy theorem and the law of conservation of mechanical energy in the solution of problems, and computing mechanical power
- Develop positive attitude towards the wise use of energy.

Competencies	***Contents***	***Suggested Activities***
Students will be able to: • Describe the necessary conditions for work to be done by a force • Describe the work done by a force F acting on a body at an angle θ to the horizontal • Use W=FS cosθ to solve related problems • Calculate the work done by a force of gravity on a body • Distinguish between positive and negative work. • Calculate the work done by a frictional force. • Determine the work done by a variable force. • Explain the relationship between work and energy • Derive the relationship between work and kinetic energy • Solve related problems using the relation	***4.Work,energy and power*** **4.1 Mechanical work** *(2 periods)* • work done by a constant force • work done by a variable force **4.2 Work- energy theorem** *(2 periods)* • kinetic energy • potential energy • mechanical energy	CLASS DISCUSSION: Invite students' to suggest some examples of work. List them without comment. Then categorize them as physical and non-physical work.. Definition: Work, in general, = (Force) (Displacement)cos θ Definition: Energy is the capacity to do Work. Work and energy have the same units. They are really the same quantity but viewed from different perspectives. There are 2 kinds of energy: kinetic and potential CLASS DEMONSRATIONS with student involvement of doing work against several different forces. Have a set of five apparatus set up for use by student pairs: These include: a spring oscillator, a box pushed across the floor, a double pulley hanging from a hook in the ceiling, a rubber band with a mass hanging (manipulated by the student), a large, slow pendulum. The pendulum and spring should be set in motion. Each student have large cards, labeled "Increasing KE" and on the back "Increasing PE". One by one in the demonstrations the students should, with voice and cards comment on the process.. Start with the pendulum. Students explain their choice, stopping the apparatus if needed. If a mistake is made, another student takes his or her place. The instructor asks, "Where is a force moving across a distance? When students are comfortable labeling the process. The instructor increases the complexity by adding a card: "work done by gravity" "Work done by the spring" And "Work done by the Person" also "Work done by the rubber band" "Work done by the person". cass demonstration: A spring oscillating. Kinetic energy becomes potential, and then becomes kinetic.

Competencies	***Contents***	***Suggested Activities***
between work and kinetic energy. • Show the relationship between work and potential energy as W= - ΔU • Describe the gravitational potential energy • Describe the elastic potential energy. • Solve related problems using W= - ΔU • Explain the mechanical energy as the sum of kinetic and potential energy • State the law of conservation of mechanical energy	 **4.3 conservation of energy** *(6 periods)* • the law of conservation of energy	Peer Instruction on Kinetic and potential energy: Pendulum: When is PE the largest? Bouncing ball, when is KE the smallest? Ball on a rope vertically. When is KE largest? When is PE largest? Ball on a rope horizontally. When is KE largest? Answer it is always the same velocity. This is rotation. We'll study that later. Masses on springs: when is KE/PE largest? A Work Energy Jeopardy: Match definitions with the term. Include numerical calculations. Card: 5 Nt meters Answer: what is the work done by a 5 Nt force moving one meter. Include Friction terms also. 25 kg m^2/sec^2 Answer: what is a kinetic energy of a 25 kg mass moving at 1 m/sec? PE = Mgh For a spring PE = ½ k d^2 where k= spring constant. Force for a spring = k x Peer Instruction on Work and Energy and give Many examples. Definition: Energy is the capacity to do Work There are two kinds of energy: kinetic and potential TEXT: The general expression of work is W= F x D this means that work is done only by a force in the direction of motion. Work is a scalar; both F and D are vectors. In the case of pulling an object at an angle, only the horizontal force working against friction is doing work. First confirm understanding of forces. There are many terms here gravity, friction, normal force, force on the block. Peer instruction: Do many examples with very simple numbers. Count the number of forces. Zero friction, Some friction Horizontal pull Angled pull. Pick m= some integer like 12 Pick F= an integer like 10 divisible by 5 "Which one is the normal force?" Show diagram. If μ=0.2 then what is the total vertical force? What is the total horizontal force? Give a FBD. Is it complete? What is missing? Here, students' participation is needed. Do examples using masses and 37 degrees. Or 53 degrees Do some very simple problems using Peer Instruction.

Competencies	*Contents*	*Suggested Activities*
		If work was done to move the block, where did the energy to do the work come from? • Use practical examples to clarify the concepts. Hold discussion with the students. TEXT Momentum must be conserved. The total energy must be conserved. There is a slight problem in using the conservation of energy theorem every where. Sometimes energy is "lost" as a form of heat through friction. It is not really lost, but made invisible in the molecular motion of atoms. We shall assume no loss of energy to heat. Text: we know how to solve motion problems with the Galilean equations. There is a much simpler way to do that – using kinetic and potential energy. Demonstration: Throw a ball straight up in the air. Have a calibrated paper 3 meters, calibrated in 10 cm intervals. Ask the students "What was the maximum height of the ball?" At what height did it start? My hand pushed it up with an unbalanced force. Invite students to make a FBD of the ball in your hand. What is the PE of the ball at the top? What is its KE up there? Measure the mass of the ball. Calculate the initial velocity of the ball using conservation of energy. Do the same experiment with a heavier ball? PEER instruction: Invite students to guess if the velocity is greater, smaller or the same. Do the experiment: What has changed? More peer instruction on KE and PE PE with a rubber band and horizontal vibration.
• Define the term collision • Distinguish between elastic and inelastic collision • Solve problems involving inelastic collision in one dimension using the law of conservation of mechanical energy and momentum	• collision in one dimension	Classroom demonstration: Suspend a rubber band between two fixed points. If you have a hook in the ceiling uses that, and a fixed heavy object like a desk for the bottom. Use rubber strips from a split bicycle tire. Put a weight in the center using bolts and washers. It will look like the string on a bow. Measure the spring constant of the elastic with the dynamometer in Nt/m. Pull back the weight and let it vibrate. What is the velocity of the bolt at the end of its path? What is the velocity when it is fastest? Conservation of Energy says: Energy stored in the spring = Kinetic energy when the stored energy is zero. $PE_{spring} = \frac{1}{2} k \times X^2 = \frac{1}{2} mV^2 = KE_{mass}$ Calculate the instantaneous velocity of the bolt at the middle of its oscillation using values of the elastic constant and the distance plucked. Peer Instruction:

Competencies	***Contents***	***Suggested Activities***
• Explain the energy changes that takes place in an oscillating pendulum • Explain the energy changes that takes place in an oscillating spring-mass system(1D) • Design the proper usage of energy sources • Discuss a system of	• energy in an oscillating pendulum • energy in a spring-mass system **4.4 mechanical power** *(1 period)*	What if the mass were doubled? What happens to the velocity? Confirm with experiments after group discussion. What would happen if the number of elastics were doubled? Demonstration: Get a solid rubber ball and a tennis racket. Drill a small hole in the ball big enough to put in the tip of a sensitive thermometer. Drill another smaller hole through the ball and put a wire in it. Make one end into a knot. Make the other end into a loop. Tie some very strong rubber bands onto the loop. Make the rubber bands about 1.2 m long. Invite students to bounce the ball off the floor. Start the ball at room temperature. They must bang the ball as many times as possible per minute into the floor. Discuss the flow of energy here. Where is kinetic energy, Where is potential energy? Are there other forms? When one student tires, substitute another. After about 2 minutes, take the temperature of the ball. It will be above room temperature. Why? Some of the Kinetic energy from the bouncing has been transformed into heat. Heat is the collective kinetic energy of individual atoms and molecules. Once energy has been transformed into heat you cannot get it back to more concentrated forms such as kinetic energy of the ball. All the atoms in the ball just cannot decide to go in one direction. Heat energy is a random motion. Discuss the transformation and conservation of energy for different examples, such as for :- • Falling or rising object in air like a rocket or ball • Pendulum vibration • Spring-oscillation The total energy in the universe is constant. Heat is just one form. PEER instruction. Calculate: maximum velocity of a bob on a 2Kg pendulum that has an input of 0.2 joules of PE Calculate the maximum velocity of a 1 Kg cart on a horizontal frictionless table attached to a spring with a constant of 5 Nt/m if the spring is bulled back 1.2 m. Discuss why all these calculations are very similar. Discuss the transformation of either P.E or kinetic into different forms of energy. TEXT: generation of power is very important for Ethiopia. We have not yet discussed electric energy. It is another kind of energy that is also conserved. Electric energy is generated in two ways: 1) from spinning a coil inside a magnet in a dynamo generator. These dynamos are powered either by coal, oil, falling water, wind power, or nuclear energy 2) interactions at the molecular level in photovoltaic cells. In the first case

Competencies	Contents	Suggested Activities
utilizing energies like wind energy, solar energy, geothermal energy more efficient for local use • State some renewable sources of energy • Express the formula of mechanical power in terms of average velocity • Solve problems involving the definition of power • Show that KWhr is also a unit of work(energy	• wise use of energy	energy is converted from chemical sources in the fuels, moving energy (kinetic energy) of wind or water, or nuclear energy from splitting atoms. Ethiopia depends primarily on hydro power. What are the advantages and limitations of hydro power as the potential source of electrical energy? e.g. - Kinetic energy-electricity • P.E into kinetic energy vice versa • Kinetic energy-heat etc. Build a car using rubber bands as power sources. There is no design limit on either number or kind of wheels. 1, 2, 3, 4 etc. Rubber, metal, donut shaped or cylinder shaped. The cars will compete in a competition to see which one goes the furthest. The mass of the car must be less than 1 kg. It must fit into a box that is 40 cm by 20 cm by 20 cm. You may pick any materials for the body or wheels. The distance traveled will be measured on a straight line perpendicular to the starting point. If the car's path is crooked only the normal displacement component counts as distance Students must spend several weeks, working in groups on their cars. They cannot use pre-made toy cars. They can borrow parts from them but not use whole cars. They must decide how best to store the energy in the spring and how best to transfer it to the wheels. Friction with the road is important. Too much slows the car down. Too little contact with the road and the wheels spin. The group must present a report, including a drawing of their car and explain their design decisions

Assessment

The teacher should assess each students work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level

A student working at the minimum requirement level will be able to: define and describe the concepts and units related to energy, work, and power (e.g. gravitational potential energy, kinetic energy); identify conditions required for work to be done, and apply quantitatively the relationships among work, force, and displacement along the line of the force; analyze, in qualitative and quantitative terms, simple situations involving work, gravitational potential energy, kinetic energy, and thermal energy and its transfer (heat), using the law of conservation of energy; apply quantitatively the relationships among power, energy, and time in a variety of contexts; define and describe the concepts and units related to momentum and energy (e.g., momentum, impulse, work-energy theorem, gravitational potential energy, elastic potential energy, thermal energy and its transfer [heat], elastic collision, inelastic collision); apply quantitatively the law of conservation of linear momentum; analyze situations involving the concepts of mechanical energy, and the laws of conservation of momentum and of energy; distinguish between elastic and inelastic collisions; explain common situations involving work and energy, using the work-energy theorem.

Students above minimum requirement level

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level

Students working below the minimum requirement level will require extra help if they are to catch up with rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

Unit 5: Simple Machines *(11 periods)*

Unit outcomes**:** Students will be able to:

- Develop knowledge and understanding of basic principles of simple machines ,and purposes of machines
- Develop manipulative skills in using and handling simple machines, and constructing simple machines
- Develop interest in using simple machines to do work in daily life activities

Competencies	***Contents***	***Suggested Activities***
Students will be able to: • Explain the purposes of a machine • List the types of simple machines • Define the terms: Load, effort, work-out put, work-input, MA, VR and efficiency • Derive the expression of η=MA/VR from its definition • Identify the orders of lever. • Give examples of each orders of lever • Determine the MA, VR and efficiency of lever. • Describe the pulley systems. • Explain the working mechanism of a differential pulley • Calculate the MA, VR and efficiency of a pulley system. • Derive an expression for the MA of an inclined plane with and without friction • Calculate the MA, VR	***5. Simple machines*** **5.1 purpose of machines** *(1 period)* **inclined plane, wedge, and screw***(5 periods)* **5.3 levers** *(5 periods)* • wheel and axle	Invite students to give examples of machines some complex some simple.. What do they see as a purpose of a machine? Elicit from responses explanations using terms from physics. Activity: Have a collection of simple machines set up: Pulley systems, planes, levers as previously, perhaps a bicycle and a screwdriver with a screw. Invite pairs of students to hold cards that have arrows for forces and other cards that say “Work done by the person”. As the machines move students should label the force properly and describe how the work is done. They must identify the force against which they are pushing. If there is a mistake, another student takes his/her place. Cycle through the machines till many students get a chance to work with them. A machine is a device that enables work to be done easier or faster. A machine is used to transform energy, multiply force, multiply speed, or to change the direction of a force. However a machine cannot multiply work or energy. Because the law of conservation of energy states that energy cannot be created or destroyed, meaning that the work output cannot exceed the input energy or work input. All compound machines such as automobiles, airplanes, power shovels are combinations of the six simple machines: lever, pulley, wheel and axle, inclined plane, wedge, and screw The wedge and screw are themselves variations of the inclined plane, while the pulley and the wheel and the axle are variations of the lever. Neglecting friction, in any machine the output work equals input work. Since work equals force multiplied by distance, the input (applied) force times input distance must equal the output force (resistance) times output distance ($F_id_i=F_od_o$) Solving for the output force we have $F_o=F_id_i/d_o$.From this equation it can be seen that the output force ca be magnified if the input forces F_i is moved through a great distance. A small force moved over a great distance will produce a large force moved over a short distance. One of the simplest machines is lever. When the fulcrum (pivot point) is nearer the load than the effort, a small input force will produce a large output force, because the input force moves through a greater distance than the output force. Activity: Invite students to decide which simple machines correspond to the following activities: Examine the six simple machines. Which would be used to slide a large crate from the street to

Competencies	*Contents*	*Suggested Activities*
and efficiency of an inclined plane • Describe the use of wheel and axel • Determine the MA, VR and efficiency of wheel and axle (when the load is on the axle on the wheel). • Describe the use of a jack screw. • Calculate the MA, VR and efficiency of a wedge • Describe the use of gears • Determine the MA, VR, and efficiency of a gear system • Determine whether the machines are force multiplier, speed multiplier or direction changer.	• pulleys/differential pulley • gears, chains and belts • Compound Machines	the bed of a moving van? Which would you most likely find on a door? Which would be used to split a log?? Which would be used to lift the engine from a car? Which would you use to lift a car to change a flat tire? Which would you use to pry the lid off a can of paint? Which would you use to open a coca cola bottle? Let the students make a list of ten items commonly used in the kitchen and note how many are machines? Students should experiment with a wide variety of the three types of levers and have them give many examples of each. Use diagrams to show students that a wheel and axle is actually a lever with unequal arms. Ask them to locate pictures in various magazines and advertisements that show examples of the wheel and axle, such as doorknobs, crank, can openers, and bicycles. When the effort is applied to the wheel, force is magnified. When the effort is applied to the axle, speed is magnified. A pulley system consists of one or more grooved wheels, revolving in a frame called a block, connected by a system of ropes known as a tackle, thus the familiar name, block and tackle. Let the students construct pulleys sufficient to show how pulleys operate, but there are significant frictional forces involved in their operation. Gears are a series of levers and may be used to multiply force, multiply speed, or change direction. they are used in many compound machines(machines composed of more than one simple machine)including automobiles,bicycles,clocks,and photocopy machines All compound machines are combinations of simple machines, and all simple machines are variations of two basic machines: the lever and the inclined plane. A pulley and wheel and axle are modifications of levers, while the screw and wedge are modifications of the inclined plane. Thus all complex machines, including automobiles and household appliances are combinations of levers and inclined planes. Although they may include electrical and thermal elements, their mechanical components are based upon the principle of the lever or the inclined plane. Students should realize that their body is a magnificent compound machine composed of a myriad simple machine. Your front teeth are wedges that can easily bite through a carrot because the jaw is controlled by strong muscles and acts as a third –class lever. When you stand on your tip toes your foot is acting as a second class- lever. When you lift an object upward with your hands, with the arms bending at the elbow, your forearms are acting as a third class-lever Machine jeopardy: make some cards and let the students respond. Card 1 kitchen knife? Answer: wedge Card 2 bottle opener? Answer second order lever Card3 “inzirt’(local spinning machine) Answer: wheel and axle (speed multiplier)

Assessment

The teacher should assess each students work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level

A student working at the minimum requirement level will be able to : identify, describe, and illustrate applications of types of simple machines, that is, the inclined plane and the lever, and modifications of these (the wedge, the screw, the pulley, and the wheel and axle); apply quantitatively the relationships among torque, force, and displacement in simple machines; state the law of the lever, and apply it quantitatively in a variety of situations for all three classes of levers; explain the operation and mechanical advantage of simple machines; determine the mechanical advantage. VR, efficiency of a variety of simple machines; describe the role of machines in everyday domestic life and in industry (e.g., identify simple machines that are part of a device used in the home, and explain the function of each machine).

Students above minimum requirement level

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level

Students working below the minimum requirement level will require extra help if they are to catch up with rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

Unit 6: Fluid Static *(12 periods)*

Unit outcomes**:** Students will be able to:

- Develop knowledge and under standing of pressure, density, relative density, fluid pressure at rest, atmospheric pressure and measurement of pressure
- Gain knowledge and understanding on Pascal's principle, Archimedes' principle and floatation and their applications.
- Develop skills in computing pressure, density, static pressure in a fluid, and applying Pascal's, Archimedes', floatation principles in the solution of problems, and measurement of pressure using measuring devices
- Develop interest and curiosity in properties of fluids
- Appreciate the role of atmospheric pressure in technology.

Competencies	***Contents***	***Suggested Activities***
Students will be able to : • Define the term pressure • Use the definition of pressure to solve related problems • Describe atmospheric pressure • Explain the variation of atmospheric pressure with altitude • Explain how to measure atmospheric pressure • Show that 760cmHg is equal to one atmosphere (=1.01x105 pa)	***6. Pressure*** **6.1 Air pressure***(5 periods)* • The magnitude of air pressure • Air pressure and breathing	Pressure is defined as the amount of force applied per unit area. Pressure can be measured with many different units. One of the most confusing aspects about pressure is the wide variety of units used to measure it .It is important that students realize all these units are simply different ways of measuring the same thing, namely the ratio of force to area. Activity: Atmospheric pressure at sea level is 101.3KPa.Is this a large pressure or a smaller? To understand the magnitude of atmospheric pressure, you must relate it to something with which you are familiar. You can compare atmospheric pressure to the pressure you exert on the floor. Since pressure is defined as P=F/A, you can calculate the pressure you exert on the floor if you know your weight and surface area of contact. Measure the contact area of your feet. Draw the outline of your shoe on a piece of graph paper and count the number of squares inside the figure. Multiply the number of squares by the area of an individual squares to determine the approximate surface area of the bottom of your feet. Students answer may vary depending upon their weight and the surface area of the bottom of their feet. In general, students should find that air pressure is approximately five times as great as the pressure they exert on the floor when standing on both feet. Activity: To investigate how great is atmospheric pressure, students can also perform the 'collapsing can experiment'. The tremendous pressure exerted by air can be demonstrated in a dramatic fashion using two drain plungers. When two plungers are pressed together to form a tight seal, it becomes very difficult to pull them apart. Cover the adjoining surfaces of two plungers with light grease so a good seal will form, and push them together. As the plungers collapse air escapes, and if a good seal forms, no air will enter when pressure is released. When you stop pushing on the plungers, the rubber in the head of the plunger will expand due to internal restoring forces. As the heads expand, a partial vacuum is created, causing the formation of a pressure differential between the outside and the inside of the plungers. Go outside the class and try to pull the plungers apart. Can you do it?

Competencies	***Contents***	***Suggested Activities***
• Define the term fluid • State the similarities and differences between liquids and gases		Concepts to investigate: measuring atmospheric pressure, aneroid barometer, weather forecasting A simple aneroid barometer can be made from household materials and used to observe changes in air pressure. Obtain a wide –mouthed empty jar and seal it with a sheet of Mylar(Mylar is used in aluminized party balloons, is relatively impermeable to gas, and thereby allows balloons to remain inflated much longer than balloons made of rubber).Stretch a sheet of mylar until it forms a tight drum over the top of the jar and use heavy rubber bands to hold it in place. Place a small piece of chewing gum or other adhesive in the center of the membrane and attach the end of a spaghetti noodle, broom straw to the gum. The needle can pivot on the edge of a jar. As atmospheric pressure decreases, the pressure inside the jar will exceed the external pressure and force the membrane to bulge up and the needle to move down. Conversely, if the atmospheric pressure increases, the membrane will bend inward and the needle will swing up. To calibrate your barometer, tune your radio to a local station that reports barometric pressures. When a pressure reading is given, write that pressure adjacent to the point on your scale where the needle is pointing. Although your barometer may not be accurate, you should be able to observe major changes in barometric pressure. Observe your barometer over a one – or two – week period determine if there is a relationship between changes in barometric pressure and changes in weather.
• Define the terms density and relative density • Determine the density and relative density of a body in a given problem • Explain how the pressure in a liquid at rest varies • Apply the formula P=ρgh to solve related problems • Calculate the total pressure on a body inside a fluid using the formula Ptotal= Patmo + ρgh	**6.2 Fluid pressure** *(7 periods)* • Siphons • How does water pressure vary with depth	Vacuum cleaners: an electric motor drives a fan that pushes air out the back of the cleaner, leaving a partial vacuum in the dust bag. Outside air pressure pushes dirt and other debris into the bag. Text:
	• Pascal's principle	A fluid is a substance that flows easily and takes the shape of its container. Both gases and liquids flow and are considered to be fluids. The pressure of a fluid is given by $P_{(fliid)} = \rho gh$, since g is constant and the densities of most fluids are relatively constant with depth, the principal factor influencing fluid pressure is depth. The pressure at any level beneath the surface of a fluid is the same in all directions. If, for example, a balloon is submerged in water, it will assume a smaller spherical shape as water presses equally upon it in all directions, rather than a flattened shape as if someone sat on it. The air in the submerged balloon transmits pressure equally in all directions so the balloon

Competencies	*Contents*	*Suggested Activities*
• State Pascal's principle • Use Pascal's principle to explain the function of a hydraulic lift(press) • Apply Pascal's principle to solve related problems • Explain the use of manometer • Demonstrate understanding of atmospheric pressure, gauge pressure and absolute pressure • Distinguish between absolute pressure and gauge pressure. • Calculate the absolute and gauge pressure of a fluid in a container • State Archimedes's principle • Distinguish between true weight and apparent weight of a body • Calculate the buoyant force acting on a body in a fluid • State principle of floatation	• Archimedes' principle	maintains a spherical shape. Pascal's principle states that fluids transmit pressure equally in all directions. Activity: Construct a U-tube by bending a section of glass tubing .Alternatively you may use two straight pieces of glass connected by an arc of flexible tubing. Add water to the U-tube until it is approximately half full. Measure the height of the water in both arms and record it in a table. Using a pair of scissors, cut a section from a large balloon big enough to fit over the opening of a small funnel. Stretch the material over the opening and secure it with rubber bands if necessary. Connect tubing to the end of the funnel and one end of the U-tube .Immerse the funnel in water and record any changes in the levels of the water in the u-tube. A rise in the column of water in the open side of the u-tube indicates an increase in pressure on the funnel membrane. Carefully measure the change in height within the tube and record it in the table. Invert the funnel, keeping the membrane at the same level, but facing the reverse direction. Again record the height of the water column. Repeat the procedure, holding the funnel horizontally so that the middle of the funnel is at the same level. After completing three measurements at the same level, move the funnel dipper and take three additional measurements. What is the influence of depth on pressure? On the basis of your data is fluid pressure directional? Is pressure greater in one direction than another? Archimedes stated that any object submerged or floating in a fluid is buoyed upward by a force equivalent to the weight of a fluid it displaces. Flat sheet of heavy –gauge sheet metal will sink because its weight exceeds the buoyant force. If, however the metal is bent, to form a hollow block it may displace more water and be subjected to a greater buoyant force. Activity: Using pliers let the students build their own sheet metal boat. If metal is not available they may use aluminum foil. Using Archimedes' principle, let the students explain why their boat will sink if placed on its side? Activity: Form a group among the students to calculate the buoyant force: Suspend a metal object in air from a spring balance, and record its weight in the table. Fill a beaker with water until it overflows. Once water has stopped flowing, place a dry graduating cylinder or other container beneath the spout of a beaker. Hang the object from the scale and slowly immerse it in the beaker such that all of the displaced water flows over the spout and in to the graduating cylinder. Record the new weight of the submerged object. The weight of water displaced can be measured by collecting and weighing all the water that overflows from the beaker. Analyze the results recorded in the table. Is the weight of the displaced water equal to the difference in the weight of the object when measured in air or in water?

Competencies	*Contents*	*Suggested Activities*
• Explain why bodies float or sink • Calculate the density of a floating body or density of a fluid using floatation principle		

Assessment

The teacher should assess each students work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level
A student working at the minimum requirement level will be able to : define and describe the concepts and units related to fluids(e.g., density, atmospheric pressure, absolute pressure, pressure, volume); identify factors affecting static pressure, analyze static pressure in quantitative terms, and explain its effects in liquids and gases; state Pascal's principle and explain its applications in the transmission of forces in fluid systems; state Archimedes' principle and explain its application.

Students above minimum requirement level
Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level
Students working below the minimum requirement level will require extra help if they are to catch up with rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

Unit 7: Temperature and Heat *(12 periods)*

***Unit outcomes*: Students will be able to:**

- Develop knowledge and understanding of temperature, heat, thermal expansion of substances, quantity of heat, and change of state
- Develop skills in computing the amount of heat, specific capacity and latent heat and thermal expansion of materials
- Appreciate the importance of the high value of specific heat capacity and abnormal expansion of water.

Contents	*Competencies*	*Suggested Activities*
Students will be able to: • Explain the difference between heat and temperature • Define the term thermal equilibrium	***7. Temperature and Heat*** **7.1 Temperature and heat energy***(2 periods)* • Heat and temperature • Thermal expansion. • Heat as molecular motion • First law of thermodynamics • Second law of Thermodynamics (qualitative treatment)	Demo: Materials: solid rubber ball. Drill a hole into it that will just fit a thermometer. Drill a second hole with a much thinner drill so that a thin but strong wire can go through, like a paperclip. Put the wire or paper clip through and bend over one end so it cannot come out. Attach a tough set of rubber bands to the wire, and then attach that to a board shaped like a tennis racket. The ball should bounce off it easily. Make the length of the rubber bands about 1/3 meter. Take the temperature of the ball. Invite a student to come up and pound the ball off the floor mightily. Ignore the student while you invite the class to share ideas about heat energy. What is it? Is it a fluid? Is heat a thing? Be theatric, if the student stops pounding, remind him of his job Continue polling the students for ideas of heat. Could it be a fluid inside substance? Why and why not? Remind the student to keep pounding. After about 5 minutes, take the temperature of the ball. Why did it go up? Invite answers. Could heat be a fluid from this experiment? Common language treats heat as something that flows from a fire or a hot tip of metal to a colder end. Students should appreciate that heat is not a substance; it is vibration of atoms or molecules in the substance. Students should appreciate that it is possible for kinetic energy to be transformed into internal vibrations of molecules.
• Describe the thermal expansion of solids • Derive the expression of linear expansion of solids • Derive the expression of surface(a real) expansion of solids • Find the relationship between coefficient of	**7.2 Expansion of solids liquids and gases** *(3 periods)*	TEXT: The teacher brings out a "magic wand" he claims can "talk to atoms" It is a ridiculous stick with feathers bells and colored paper. He puts the heated ball on a table and holds the stick near the ball and the paddle on top of the stick. "I want all of you atoms inside to start moving in the same direction, up and down and start bouncing." Nothing happens; he moves to another table and asks students to help. Why cannot all the atoms decide to move in one direction, upwards and then start bouncing again? Invite student responses. Students should appreciate that heat is totally random motion of atoms and molecules. The

Contents	*Competencies*	*Suggested Activities*
linear, area and volume expansion • Mention applications of thermal expansion of materials (bimetallic strip, thermostat) • Solve problems involving linear, area and volume expansion of solids • Distinguish between apparent and real expansion of a liquid • Solve problems involving expansion of liquids using the formula $V=V_o\gamma\Delta T$ • Explain the abnormal expansion of water • Compare the expansion of gases with expansion of solids and liquids		motion cannot be re-ordered to something like kinetic energy of a body. Heat is motion energy at an atomic and molecular level. There is no way to convert that kind of motion into something else, like kinetic energy. This is the second law of thermodynamic. It, like Newton's laws and the conservation laws is one of the great universal principles. Random motion cannot be undone. It also means that time has a direction, some processes cannot be reversed. Students already know the first law: it is the conservation of energy. PEER INSTRUCTION Invite students to explain why heat is not temperature. Invite examples from groups of students citing specific physical situations in which heat and temperature are not the same. Return to the bouncing ball. How does this experiment show conservation of energy. What is the source of the energy? All increase in heat causes more atomic motion. This causes more pressure in gases, balloons expand. It causes dimensions to change in solids and liquids. This is how mercury and alcohol thermometers work Demo:
• Define the terms: specific heat capacity and heat capacity of a body • Describe the factors that affect the amount of heat absorbed or liberated by a body • Identify different units of heat energy • Calculate the quantity of heat absorbed or liberated by a body using the formula $Q=mc\Delta T$ • Calculate the heat capacity of a body	**7.3 Quantity of Heat, Specific heat capacity and Heat capacity** *(3 periods)* • Heat exchange (calorimetery)	Have a sheet of metal with a hole in it and a ball that fits right in when cold. If the sheet is heated will the ball fit in also? Demonstration: A bolt and nut fit well together. Heat the nut, will the bolt fit on? Why? Demonstrate: Have a balloon tethered at air temperature. Measure its circumference. Hold it over a candle flame at a sufficient distance not to injure the rubber for a few minutes to heat the air. Measure the diameter of the balloon. Discuss the basic kinetic theory of matter with students (qualitatively) • State the effect of temperature on the motion of particles (qualitatively) • Recapitulate the effects of heating a body. • Demonstrate expansion of solids, liquids and gases. Presentation: Show the graph of the heat needed to raise 1 gram of water from -5 C to 110 C. DEMO: start water heating in some container. Use electricity or an alcohol lamp. Use a small amount. When it is boiling, keep reading the temperature. Why is it not increasing? Heat is going in? TEXT: introduces latent heat of vaporization 580 j/g/ for water.

Contents	*Competencies*	*Suggested Activities*
• Explain the significance of high specific heat capacity of water • solve problems involving heat exchange using the relation: Heat lost = Heat gained • Describe the uses of calorimeter. • Define the term latent heat • Define the term: latent heat of fusion, latent heat of vaporization. • Solve problems involving change of state	 **7.4 Change of state** *(4 periods)* • Latent heat	Introduce latent heat of melting/fusion for water. Group work - assessment: assign each group of 5-6 students a specific amount of water in a jar or cup. Make it range from 12g to 2 kg. How much heat will it take to get that amount of water to 110 C?

Assessment

The teacher should assess each students work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level

A student working at the minimum requirement level will be able to :define the terms: thermal equilibrium, thermal expansion change of phase, calorimetry, latent heat capacity, heat latent heat of vaporization, latent heat of fusion; identify the units for the terms: heat, heat capacity, specific heat capacity, latent heat: state the relationship between heat transferred and observed change in temperature; solve problems involving calculations of heat lost, heat gained, change of phase, expansion of materials.

Students above minimum requirement level

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level

Students working below the minimum requirement level will require extra help if they are to catch up with rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

Unit 8: Wave Motion and Sound *(16 periods)*

***Unit outcomes*: Students will be able to:**

- Develop knowledge and understanding waves, types of waves, periodic motion,, wave motion, characteristics of waves, and properties of waves.
- Develop knowledge and understanding of sound waves, properties of sound, wave and characteristics of sound.
- Develop skills in computing the speed, period, frequency of a wave in the solution of problems.
- Develop skills in computing the intensity of sound waves.
- Appreciate the application of reflection of sound wave, and the role of waves in technology.

Competencies	***Contents***	***Suggested Activities***
Students will be able to: • Define the terms: wave, pulse	***8. Wave motion and sound*** **8.1 Wave propagation** *(4 periods)* • Pulse and train of wave • Types of waves Mechanical and electromagnetic waves	Invite students thought on the meaning of a physical wave. Where do you see them? What types are there? Invite students' responses. List them. Use a large tray to demonstrate waves in water. Use a rope to demonstrate waves. CLASSROOM LABORATORY: the Human Wave: Lab simulation #1. Stretch the slinky down one row of students. Use more than one slinky taped together if needed. Students are models for molecules of water. Make a ripple at one end of the slinky. They will simulate the motion of a wave in the water. Model the motion of a wave down the slinky powered by students several times.
• Define the terms: crest, trough, wave length, amplitude, frequency, period of a wave. • Solve problems involving wavelength, frequency and wave speed	**8.2 Mechanical Waves** *(4 periods)* • Characteristics of waves • Wave equations	Lab Simulation #2. Bring in a basket ball. Move to another row of students. Go to the middle of the class and "drop" the basketball into the end of the "water" simulated by the slinky .Students imitate motion with the slinky as if it were the motion of the water waves. At the end they go down, and then up, and the wiggle moves down the slinky to the end of the row. Lab Simulation #3. Bring in the idea of time. Add a new rule. Use some timing device that makes a sound every second or every 2 seconds. It could be a long pendulum. The rule is the top of the wave must move at exactly one desk every beat of the pendulum (every one or preferably two seconds). The teacher starts the wave at the front end, not in the middle. This row of students practices making the wave move with exactly this speed – one desk every second. If there are seven rows it will take about seven seconds for the wave to go to the back. Students model this speed of the wave several times. One wave only moves down the row. Lab Simulation # 4.The teacher stops the wave and defines two new ideas – speed and reflection. The last student acts like the wave bounced off the wall. As the wave moves down the row then back to the start position, teacher asks the other rows "What exactly is the time it takes the wave to move from the front, to the back, then to the front again? The rule is that the top of the wave must move at one desk per pendulum hit. Students time the wave. They measure the distance between the middle of the desks. They calculate the speed in meters per

Competencies	Contents	Suggested Activities
	• Transverse and longitudinal waves **8.3 Properties of waves** *(4 periods)*	second. Lab Simulation #5 Using a bridging metaphor idea, the instructor invites the students to make a model of the wave – peak to peak is one desk. He takes a piece of hose to visibly model the wave between two desks. Make the hose about 1.5 m long. It makes a shape like part of a sine wave. This is one cycle of the wave. This is an exceptionally important idea. This is the period of the wave. The "Human Water Wave" has a period of one (or two seconds). He changes the shape of the hose to a more traditional: zero to top to zero to bottom to zero shape by "sliding of an end – middle to top and moving it to the front. This is the wave length of the wave. This is the traditional way to draw one cycle of a wave as one wave length. LAB SIMULATION #6 The teacher "fires" that row and moves to another row that has not done "The wave". They practice with the basketball "drop" with a peak moving one desk at a time. The teacher writes down: Definition: one cycle = mid to top to mid to bottom to mid = One period = one cycle. The period is usually written T, as P is all ready taken with momentum. Definition: Frequency = number of periods per second. Our "human wave" is one cycle per second. or perhaps one cycle per 2seconds (if the time was 2seconds.). Frequency is traditionally represented by small f. Capital F is reserved for force Its frequency is: $f = \frac{1cycle}{\sec}$ Definition: Wave length. Wavelength is the physical distance from one end of a cycle to the other. The symbol for wave length is the Greek letter lambda λ. Collect the slinky. "What is the speed, in meters/sec of our human wave? " Invite students to suggest and defend their ideas of what the speed of the wave is measured in the objects of their classroom. It is the distance traveled in one cycle of the wave. This is the distance between two desks, about one meter or a bit less. Students measure the distance between desks. λ = about 1 meter. So, writing on the board we have: Speed of the wave = (distance peak-peak)/period Speed of the wave = λ/period But period = 1/(frequency) = $\frac{1}{f}$ so

Competencies	Contents	Suggested Activities
		$speed = \frac{\lambda}{\frac{1}{f}} = \frac{\lambda}{\frac{1}{f}} \times \frac{f}{f} = f\lambda$ Rewriting this equation neatly we get: $speed = f\lambda$ This is one of the great equations of physics. It is not a law, rather it is in the form of a definition as frequency, cycles, and distance and speed are all known quantities. In the case of light a special symbol is used The letter small c is reserved for the speed of light $3 \times 10^8 \, m/\text{sec}$ The substitution, valid only for light is: $c = f\lambda$. This is a special equation that must be remembered. The instructor writes down speeds of other waves. The speed of sound is 343 m/s.
• Distinguish between mechanical waves and electromagnetic wave		The physics of tsunamis and of waves in water is complicated in general. We offer a simple version here. In deep water the water molecules oscillate as the waves come through in circles. If the water is shallow, the bottom part of the cycle drags on the earth and slows it, so that the wave elongates. Eventually the bottom slows more than the top and the wave breaks with white tops. The speed of waves in water depends on depth for many reasons. Water molecules stick to each other in beads on a surface and even in liquid depths. This affects the wave passing through the water medium. The depth of the water medium affects the speed of a water wave. The equation is $v = \sqrt{gd}$ This equation is not a great law of physics. It is derived by analysis using Newtonian principles and applies only to limited case of water waves. It should not be memorized. Activity: Qualitative looking at the equation: $v = \sqrt{gd}$ In student groups make predictions about the relative speed of water waves in deep oceans, in small ponds or rivers, or in a pool, or thin layers in a plate. The instructor collects ideas from groups about what they think will happen to the velocity of water waves. Some may offer calculations. Record them. Activity: Board calculation: The depth of the ocean is about 4,000m. What is the speed of a tsunami, a giant ocean wave caused by an earthquake, in the open? It is about 700 kph. This is as fast as a jet plane. It slows when it approaches land as the

Competencies	***Contents***	***Suggested Activities***
		bottom encounters friction with the land. Its wavelength is very long – about 50 km or longer. What is the frequency of a group of tsunami waves? Activity: qualitative investigation outside class. Ask students to explore at home observations of the speed of waves. What happens to waves as they come ashore? What observations can you make of waves made in a shallow area, and waves made in deeper water? Collect observations: do they fit the equation? If not repeat the experiments. Demo: Students put out their hands. Each hand is a water molecule. The teacher "drops" a tennis ball on one end. Students' hands move simulating the wave at speed of one desk per second. It was a tennis ball, not a basket ball dropped the same speed. How does this affect the wave you are simulating? Students do another simulation of a "tennis ball" wave. Definition: The Amplitude of a wave is the difference in height between the middle point and the highest or lowest point. It is a measure of the energy in the wave. Activity Discussion: Discuss what has happened with the "hand waves". Which way did the wave move? Did the individual particles of the students' hands move? If "yes" which way? What does oscillation have to do with this? Students should understand that the motion of the water molecules is always about one center point. They molecules oscillate they do not move with the wave's direction. The wave is a vibration that moves across the water in a direction perpendicular to the motion of each of the water molecules.
		Water waves can carry tremendous power in Tsunamis caused from earthquakes under sea. At sea the tsunami can be 4-6 ft (1.2m-1.8m) high, Approaching land the wave's bottom drags on the ocean floor. It causes the wave to peak. Tsunami's can be a 500 to 1,000 m high hitting land.
• Identify transverse and longitudinal waves in a mechanical media(string, spring, water, seismic		Kinds of Transverse waves: Water surface waves in earthquakes (the ground wiggles up and down from a wave in the earth) and light. Class demonstration: longitudinal waves. Using the same set up of the slinky with students as the medium demonstrate a compression wave. The instructor brings together a ½ m segment of the slinky. It rebounds. The students holding the slinky representing the medium oscillate horizontally about its position. The wave proceeds away from the initial point by compressing on the same direction as its motion. Students move a series of compressions down the slinky at a constant speed. This wave is harder to model. It is not quite as visible as the transverse wave. Ask students what they think the wavelength of a compression wave might be? It is the

Competencies	*Contents*	*Suggested Activities*
		distance between compressions. Invite students to think of what the period of a longitudinal wave might be: It is the time between arrivals of a compression. Collect the slinky. Classroom demonstration: Longitudinal waves. Use a row of students that did not participate. Do not use a slinky. Ask students to twist to sit sideways a bit. Put out hands so they touch. They should keep arms stiff. Push the first one. Watch the compression go down the row. Invite the last student to put his hand on the wall. When he gets compressed and moves toward the wall, Newton's 3rd law says the wall pushes back. Longitudinal waves model reflection very easily. Invite the students to model compression and reflection off a surface of a wave. Invite students to describe their motion. Is there a total displacement? Students must appreciate that in longitudinal waves molecules oscillate and return to their positions. Sound is a longitudinal wave.
• Identify that sound wave is a longitudinal mechanical wave. • Explain about the production of sound • Describe how sound is propagated in a material medium • Define the terms: compression, rarefaction • Compare the speed of sound in solids, liquids and gases. • Determine the speed of sound in air at any given temperature	**8.4 Sound waves** *(4 periods)* • Production and propagation of sound • Speed of sound in different media • Speed of sound in air	Demonstration; Have a speaker play one tone, a buzz perhaps. Place some very light paper or fuzz on the speaker. Aim the speaker up. Observe the particles. Some students may gently feel the paper cone of the speaker. It is vibrating in and out pushing the sound out. It is making waves in the air that are compression waves. It is pushing and pulling the air. This is sound, a longitudinal wave. Water molecules, unlike air molecules are not very compressible. Sound does travel in water, but at a very different speed than in air. Classroom project: The speed of sound is 331 m/s in air. The speed of light is virtually instantaneous. Make a table for calculation of the distance of a lightening bolt by measuring the time between the flash and the sound. Make a large string as from a musical instrument. Tighten it and pluck it. Listen to the sound. Invite students to guess what its wavelength might be. Its wavelength is twice the length of the string. Using the wave equation calculate the frequency of the sound. Bring in some string instruments. Use the wave equation to calculate the frequency of low pitches and of high pitches. Define Spectrum: It is a collection of all possible frequencies. With sound this means all possible pitches from very low to very high. Invite students to share knowledge about frequencies of sound that humans can hear, and perhaps about frequencies animals can hear. Elephants can hear extremely low frequencies. They communicate over miles with sound humans cannot hear. Dogs hear very high frequencies humans cannot. Bats hear extremely high frequencies, up to 50,000 cycles/second.

Competencies	Contents	Suggested Activities
		The unit cycles per second is called the Hertz, abbreviated Hz. Classroom Demonstration: Invite a row of students to model a longitudinal wave using the Human Wave model. Start the wave with one. How is it reflected off the wall in the back? Do a quick quantitative calculation of the speed of the "human longitudinal wave" What is its speed if you know the distance in meters front to back and then to front again? Invite students to think of a way they, themselves could measure the speed of sound outside? Group Activity: Find a spot with a big reflecting wall. Move around till you can hear an echo. Make a sharp noise like clapping wood together. Move around and use a second hand on a watch till you get an echo back in one second. What is your calculation for the speed of sound? Bring it back to the classroom. Make a plot of all measurements. There should be several dozens of them. Is the set of measurement accurate? Is the accepted value in the range the class has measured? Is there systematic error? How big is it?
	• Reflection of sound • Application of reflection of sound	Make a Human Wave in another row. Do not use a slinky. Students twist 90 degrees and connect by holding hands or forearms. The instructor makes a horizontal wiggle on one end. Students model the wave moving down the row. The student at the end holds onto the wall. He must lean back as the wave hits, and then lean forward as he returns to vertical. The transverse wave now comes back to the front. Discussion: How is this different from the compression wave? Or is it the same? Refraction is most important commercially with light, so we'll model it there. Light travels slower in denser mediums. Glass or water are denser than air, so light is slower in these media. Diamonds are very dense. Light travels very slowly in diamonds. PEER INSTRUCTION on Waves Find some examples. Confirm understanding. Classroom assessments Wave Jeopardy. Make some cards: Huge ocean wave.
• Define the terms intensity of a sound • Solve problems involved intensity of sound using the formula I=power/Area • Explain the effect of refraction of sound	• Characteristics of sound	Answer What is a tsunami? 700 Km/hr. What is the speed of a tsunami? Speed = f * lambda What is the wave equation? Diagrams like coming into a denser medium. What is refraction? Coming out of a denser medium diagram.

Competencies	*Contents*	*Suggested Activities*
• Explain the difference between echo and reverberation • Describe some application of reflection of sound • Describe the characteristics of sound: pitch, loudness, Quality • Define the terms: diffraction, interference • Describe the characteristics properties of waves: reflection, refraction, diffraction, interference		What is refraction? Simple numerical problems with the wave equation. 331m/s What is the speed of sound? $3x10^{8}$ m/s What is the speed of light? Board experiment: All waves move outward from the source in all directions. They dissipate off into space until absorbed by some substance. Consider the rate at which it dissipates. Model with a rope with a chalk, how sound, light or water get weaker moving away from the source.

Assessment

The teacher should assess each students work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level

A student working at the minimum requirement level will be able to : define and describe the concepts and units related to mechanical waves (e.g., longitudinal wave, transverse wave, cycle, period, frequency, amplitude, wavelength, velocity, superposition); describe and illustrate the properties of transverse and longitudinal waves in different media, and analyze the velocity of waves traveling in those media in qualitative terms; compare the speed of sound in different media, and describe the effect of temperature on the speed of sound; draw, analyse, and interpret the properties of waves (e.g., reflection, refraction, diffraction, interference) during their transmission in a medium and from one medium to another, and during their interaction with matter;

Students above minimum requirement level

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level

Students working below the minimum requirement level will require extra help if they are to catch up with rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.