STAWA DEPTH and BREADTH of CONTENT: Teacher Support Documents

Senior Secondary Science WACE 2015 – 2016: Physics - Unit 2

The STAWA Depth & Breadth of Content documents have been developed through the collaboration of teachers working in Department of Education, Catholic Education and Independent Schools.

Purpose

The STAWA Depth & Breadth of Content documents are intended to promote a shared understanding of the course content that improves moderation across schools, regions and systems/sectors.

Caution

The Depth and Breadth points of elaboration are interpretations. The ATAR syllabus content statements are the only parts of these documents that are mandated. Examiners are required to address the mandated statements only.

The STAWA Depth & Breadth of Content documents are a great example of teachers helping teachers for the benefit of all students.

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Leadership in Science Education

PHYSICS
ATAR Year 11
Unit 2 – Linear motion and waves

Unit description

Students develop an understanding of motion and waves which can be used to describe, explain and predict a wide range of phenomena. Students describe linear motion in terms of position and time data, and examine the relationships between force, momentum and energy for interactions in one dimension.

Students investigate common wave phenomena, including waves on springs, and water, sound and earthquake waves.

Contexts that can be investigated in this unit include technologies such as accelerometers, motion detectors, global positioning systems (GPS), energy conversion buoys, music, hearing aids, echo locators, and related areas of science and engineering, such as sports science, car and road safety, acoustic design, noise pollution, seismology, bridge and building design.

Through the investigation of appropriate contexts, students explore how international collaboration, evidence from a range of disciplines and many individuals, and the development of ICT and other technologies have contributed to developing understanding of motion and waves and associated technologies. They investigate how scientific knowledge is used to offer valid explanations and reliable predictions, and the ways in which it interacts with social, economic, cultural and ethical factors.

Students develop their understanding of motion and wave phenomena through laboratory investigations. They develop skills in relating graphical representations of data to quantitative relationships between variables, and they continue to develop skills in planning, conducting and interpreting the results of primary and secondary investigations.

Learning outcomes

By the end of this unit, students:

1. understand that Newton's Laws of Motion describe the relationship between the forces acting on an object and its motion
2. understand that waves transfer energy and that a wave model can be used to explain the behaviour of sound
3. understand how scientific models and theories have developed and are applied to improve existing, and develop new, technologies
4. use science inquiry skills to design, conduct and analyse safe and effective investigations into linear motion and wave phenomena, and to communicate methods and findings

5. use algebraic and graphical representations to calculate, analyse and predict measurable quantities associated with linear and wave motion
6. evaluate, with reference to evidence, claims about motion and sound related phenomena and associated technologies
7. communicate physics understanding using qualitative and quantitative representations in appropriate modes and genres.

Unit content

This unit includes the knowledge, understandings and skills described below.

Science Inquiry Skills

1. identify, research and construct questions for investigation; propose hypotheses; and predict possible outcomes
2. design investigations, including the procedure to be followed, the materials required, and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics
3. conduct investigations, **including the manipulation of devices to measure motion and sound** safely, competently and methodically for the collection of valid and reliable data
4. represent data in meaningful and useful ways, including using appropriate Système Internationale (SI) units and symbols, and significant figures; organise and analyse data to identify trends, patterns and relationships; identify sources of random and systematic error and estimate their effect on measurement results; identify anomalous data and calculate the measurement discrepancy between the experimental results and a currently accepted value, expressed as a percentage; and select, synthesise and use evidence to make and justify conclusions
5. interpret a range of scientific and media texts, and evaluate processes, claims and conclusions by considering the quality of available evidence; and use reasoning to construct scientific arguments
6. select, construct and use appropriate representations, **including text and graphic representations of empirical and theoretical relationships, vector diagrams, free body/force diagrams, wave diagrams and ray diagrams**, to communicate conceptual understanding, solve problems and make predictions
7. select, use and interpret appropriate mathematical representations, including linear and non-linear graphs and algebraic relationships representing physical systems, to solve problems and make predictions
8. communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific reports

Green: specific content related to Unit 2. The rest of the statements are the same generic ones across the units

Science Understanding: Linear Motion

Syllabus Statement	Elaboration	Activities	Assessment opportunities
1. distinguish between vector and scalar quantities, and add and subtract vectors in two dimensions	Vector and scalar quantities • Develop a list of Scalar only quantities including units and symbols. • Head to tail vector addition. • Resolution of a vector into component to find magnitude and direction. • Use resolved components to add or subtract vectors at any angle.	Basic 2-3 Newtometer systems. Addition of vectors to show when a system is in equilibrium. Resolving vectors practical	Practical test: Vector Addition. A set of forces acting on one stationary mass (spring balance at these points), if two forces are known from spring balance, students to find the third force.
2. uniformly accelerated motion is described in terms of relationships between measurable scalar and vector quantities, including distance, displacement, speed, velocity and acceleration	Describing motion • Definitions of speed as rate of change of distance; v = rate of change of s, a = rate of change of v. • That acceleration equations only apply when the acceleration is uniform. Vav= (v+u)/2 in restricted conditions	Simple s/t and v/t graphs with gradient determination. Video capture activities. Motion probes etc. Algebra revision	
This includes applying the relationships			
$v_{av} = \frac{s}{t}$, $a = \frac{v - u}{t}$, $v = u + at$, $s = ut + \frac{1}{2}at^2$, $v^2 = u^2 + 2as$		Worksheets on formula rearrangement	
3. representations, including graphs, vectors, and equations of motion, can be used qualitatively and quantitatively to describe and predict linear motion	Graphing • Determining a from a v/t graph. v from a s/t graph. Work from s/t to a v/t graph and vice versa. • Dimensional analysis of gradient and area under the curve to determine their significance. • Instantaneous velocity	Real time data collection through video analysis. Ticker timers. Motion Sensors eg. PASCO and VERNIER.	Practical test: graphical analysis

4. vertical motion is analysed by assuming the acceleration due to gravity is constant near Earth's surface	Vertical motion and g • Calculations involving upward and downward values of u and g • Acceleration down the incline plane= gsinθ	Determination of g from a video analysis. Determine g from pendulum. Can compare the results of speed of sound to see which method is more accurate.	Inclined Plane prac
5. Newton's three Laws of Motion describe the relationship between the force or forces acting on an object, modelled as a point mass, and the motion of the object due to the application of the force or forces	• First Law = If Fnet= 0N, there is no change in momentum. • Second = Rate of change of momentum. • Third =Momentum conservation during collision (Two objects interact F on a= -F on b) • Inertia in relation to mass • Balanced forces = Constant or zero velocity. • Unbalanced forces = Acceleration.	Truck/Car inertia. Car safety features-> SHE. F=ma type prac. Find acceleration given force and mass.	
6. free body diagrams show the forces and net force acting on objects, from descriptions of real-life situations involving forces acting in one or two dimensions	Concept of multiple forces in a system • Sum of Forces = 0. Magnitude and direction. If not in equilibrium determine Fnet. • How to draw free body diagrams of a set of forces acting on one mass away from centre of mass of the object. Friction is a force. No torque. Include tension. Apparent weight. • Free body diagram of a body on a plane.	Painting/Mass suspended systems. Object in equilibrium. Riding in lifts with scales. Force sensors.	
This includes applying the relationships			
resultant $F = ma$, $F_{weight} = m\,g$			
7. momentum is a property of moving objects; it is conserved in a closed system and may be transferred from one object to another	Conservation of momentum. • Impulse and F/t graphs (Area under curve) • Vector addition v-u for a 1D and 2D system. • Vector subtraction delta v= v-u in a closed	Exploration of airbags, safety barriers, force plates, egg drop, ballistics, roller coaster systems. Video capture of conservation event. Clickview	Practical test: Conservation of momentum

when a force acts over a time interval	system collision.	"Collisions" with support materials. 'Frictionless' airtrack with carts of different masses (Require photo gate).	
This includes applying the relationships			
$p = m\,v$, $\sum mv_{before} = \sum mv_{after}$, $m\,v - m\,u = \Delta p = F\,\Delta t$			
8. energy is conserved in isolated systems and is transferred from one object to another when a force is applied over a distance; this causes work to be done and changes the kinetic (E_k) and/or potential (E_p) energy of objects	Conservation of energy. • Energy converted into common forms. Real world examples. • Work is force applied over a displacement.	Rollercoaster designs to test efficiencies, energy loss that affects efficiency. Bouncing tennis ball. Pendulum. Newton's cradle. Find work up an incline plane.	Cutting string on a moving pendulum
This includes applying the relationships			
$E_k = \frac{1}{2} m\,v^2$, $E_p = m\,g\,\Delta h$, $W = F\,s$, $W = \Delta E$			
9. collisions may be elastic and inelastic; kinetic energy is conserved in elastic collisions		Ballistics. Throwing medicine balls whilst on rollerskates Bouncing basketball with tennis ball on top. Proton/proton interaction in LHC. Pool table physics. Give sporting examples for inelastic collisions.	
This includes applying the relationship			
$\sum \frac{1}{2} m\,v^2_{before} = \sum \frac{1}{2} m\,v^2_{after}$			
10. power is the rate of doing work or transferring energy	Power and motion • Power of a car motor up a slope. • Power of a lift. • Energy efficiency- where energy is 'lost' discuss friction.	Using electric motor to lift a mass. Pile driver applications	
This includes applying the relationship			
$P = \frac{W}{t} = \frac{\Delta E}{t} = F\,v_{av}$			
SHE			

11. Safety for motorists and other road users has been substantially increased through application of Newton's laws and conservation of momentum by the development and use of devices, including: helmets, seatbelts, crumple zones, airbags, and safety barriers.			

Science Understanding: Waves

Syllabus Statement	Elaboration	Activities	Assessment opportunities
1. waves are periodic oscillations that transfer energy from one point to another	Energy transfer. • Mechanical mechanism. • Vibrating particles and mechanical movement.	Seismometer demo. Earthquakes. Microwaves->SHE. Surfing.	
2. mechanical waves transfer energy through a medium; longitudinal and transverse waves are distinguished by the relationship between the directions of oscillation of particles relative to the direction of the wave velocity	Particle movement • Ripple tanks or simulators. • Specific examples of longitudinal and transverse waves. • Difference between mechanical and non-mechanical electromagnetic waves. • Energy is transferred without permanent displacement of particles	Use of ripple tanks/slinky springs. Speaker demos - Longitudinal/Transverse. pHeT-> online simulators.	
3. waves may be represented by displacement/time and displacement/distance wave diagrams and described in terms of relationships between measurable quantities, including period, amplitude, wavelength, frequency and velocity	Graphing waves • Link pressure (Compression/Rarefaction) to displacement/time graphs. • Define period, amplitude, wavelength, frequency and velocity. • Travelling wave in slinky. Sound intensity= amplitude, sound pitch= frequency.	Microphone/diaphragm. Movement on a CRO. Students walk between two speakers set up in a classroom with same frequency. CRO simulator. Online animations	
This includes applying the relationships			
	$v = f\lambda$, $T = \frac{1}{f}$		
4. the mechanical wave model can be used	• Define refraction. Velocity of sound changes with	Clap/tube and echoes. Speed of sound determination using echoes.	Assessed prac- Determine the

to explain phenomena related to reflection and refraction, including echoes and seismic phenomena	properties of air/Change in medium. • Define reflection. Define critical angle (Qualitative only) • Apply concept of refractive index.	Light boxes. Fibre optics (NBN). Vibrating string, observe standing waves. Modelling processes with students as waves. Air column experiment as in STAWA manual. Resonance pipes. Kundt apparatus. Use sound gun across field. Application- Galloping Gertic bridge broke.	speed of sound with tuning fork and raising and lowering in water column.
5. the superposition of waves in a medium may lead to the formation of standing waves and interference phenomena, including standing waves in pipes and on stretched strings	Interference patterns. • Destructive and constructive interference. • Define phase and phase change. • Describe formation of standing waves.		
This includes applying the relationships for			
6. a mechanical system resonates when it is driven at one of its natural frequencies of oscillation; energy is transferred efficiently into systems under these conditions	Standing waves. • Stretched string/Open Pipe/Closed Pipe. • Define and apply node and antinode. • Define natural frequency. • Forced vibration vs. resonance.	Determination of node/anti-nodal points. Use of musical instruments. Reuben's tube video.	Tacoma narrows bridge, millennium bridge. Natural frequency. Tuning fork swings. Microwave heating as example of resonance. Old cars rattling when they travel.
7. the intensity of a wave decreases in an inverse square relationship with distance from a point source	Intensity • No log in course. • Only focus on I vs distance. Define intensity.	Microphone and intensity activities. Sound meters/data loggers. Hearing damage -> SHE. Reduction methods. Light sensor with candle.	
This includes applying the relationship			
$I \ \alpha \ \frac{1}{r^2}$			
SHE			

8. Application of the wave model has enabled the visualisation of imaging techniques. These can include: medical applications, such as ultrasound, geophysical exploration, such as seismology	• Bionic ears, cochlear implants • Sonars / underwater acoustics	Pregnancy scans. Refractive index	
9. Noise pollution comes from a variety of sources and is often amplified by walls, buildings and other built structures. Acoustic engineering, based on an understanding of the behaviour of sound waves, is used to reduce noise pollution. It focuses on absorbing sound waves or planning structures so that reflection and amplification do not occur.	Noise cancelling head phones and microphones.	Acoustic design Reflective, non-reflective surfaces. Anechoic chambers.	
Science Inquiry Skills			
identify, research and construct questions for investigation; propose hypotheses; and predict possible outcomes			
design investigations, including the procedure to be followed, the materials required, and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics			
conduct investigations, including the manipulation of devices to measure motion and sound safely, competently and methodically for the collection of valid and reliable data	Define difference between valid and reliable data.		
represent data in meaningful and useful ways, including using appropriate Système Internationale (SI) units and symbols, and significant figures; organise and analyse data to identify trends, patterns and relationships; identify sources of random and systematic error and estimate their effect on measurement results; identify anomalous data and calculate	Focus on linear relationships. Difference between random and systematic error and outliers.		Error calculations

the measurement discrepancy between the experimental results and a currently accepted value, expressed as a percentage; and select, synthesise and use evidence to make and justify conclusions			
interpret a range of scientific and media texts, and evaluate processes, claims and conclusions by considering the quality of available evidence; and use reasoning to construct scientific arguments			
select, construct and use appropriate representations, including text and graphic representations of empirical and theoretical relationships, vector diagrams, free body/force diagrams, wave diagrams and ray diagrams, to communicate conceptual understanding, solve problems and make predictions			
select, use and interpret appropriate mathematical representations, including linear and non-linear graphs and algebraic relationships representing physical systems, to solve problems and make predictions			
communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific reports			