Lesson Plan

Subject: Physics
Unit: General Waves Properties
Topics: Describing and Understanding Wave Motion - Transverse Waves
Level: Upper Secondary Normal/Express
Duration: 90 min

Learning Outcomes (LOs):
Students should be able to:

- understand the motion of the individual particle in a wave from the Displacement-Time graph;
- understand conceptually how a (travelling) wave motion is formed by the interaction of different particles due to the source of wave.

Teaching ideas in Physics: Transverse Waves

Tip1: The periodic oscillating force generates waves through the medium with the particles vibrating with the same periodic motion.

Tip2: The particles in the medium vibrates periodically about their equilibrium position hence no mass transfer.

Tip3: The particles in the medium are held together by the bonding between them allowing energy to be transferred through them.

Prior Knowledge/Pre-Requisite Knowledge of Pupils:
Students should be able to

- apply the concepts of speed and velocity
- deduce from the shape of a displacement-time graph when a body is:
  (i) at rest
  (ii) moving with uniform velocity
  (iii) moving with non-uniform velocity

Common Learning Difficulties and Misconceptions:

1. Students have difficulty in visualizing the particles motion in waves
2. Students have difficulty visualizing subsequent motion of particles in a wave motion
3. Student have difficulty explaining the motion of waves in terms of the particles movement.
4. Students think that all sound waves are transverse waves; this is because the displacement-distance graph of sound waves are shaped like transverse waves.
5. Students have difficulty using apps/videos to study wave properties without guidance.

Pedagogical Reasoning and Planning Guide

- Singapore Teaching Practice (STP)
- PCK
- 3Cs Pedagogical Framework for Inquiry Science (Poon, 2010) / Visualisation Based Learning

PP	Learning Activity / 3Cs	Time (min)	Resources
TA: Arousing Interest TA: Encouraging Learner Engagement TA: Using Questions to Deepen Understanding	**1st C - Capture Interest** **Engaging in a Real World Phenomenon** Making Learning Meaningful Teacher to emphasise the importance of learning wave – an understanding of Tsunami and Earth Quake (P waves and S waves) can save lives. Students to watch a demonstration of a rope wave generated by the teacher. Note: A sticker is secured on a point on the rope to indicate that point of the rope did not move in the direction of the wave – there is no transfer of mass. 1. Ask students what they observed. 2. Summarise their key observations. 3. Draw students' focus to the individual particles in the rope – students to observe carefully how the sticker move as the wave travels away from the source of disturbance. **Question: In which direction does the sticker move with respect to the wave?** 4. Introduce the single particle demo kit: Ask students to imagine that the rope is being divided into many particles with one of the particles represented by the label/sticker before introducing the demo kit for simulating a single particle motion in a wave. **Success Criteria:** ✓ Students able to see that the energy transfer through the rope is away from the oscillating force as seen by the movement of the crests away from the oscillating force. ✓ Students able to see that the rope is made up of many particles and all particles are held together by the bonding between them. ✓ Students able to see that every particle vibrates perpendicularly to the direction of wave motion.	10 min	PPT Gym rope Sticker/label Single particle demo kit set

	2nd C - Construct Understanding	40 min	
TA: Pacing and Maintaining Momentum- Managing transition from rope wave to individual particle motion **TA: Providing Clear Explanation - using Model as Teaching aid** **TA: Using Questions to Deepen Understanding** **TA: Activating Prior Knowledge- Concepts of Speed and Displacement-time graph** **TA: Facilitating Collaborative Learning**	**Learning Activity 1.1** This learning activity is the continuation of the rope demonstration; the focus is on the motion of a single particle located at a point in the direction of the wave. Teacher reiterates that the kit is based on a mathematical model used by physicists to explain the motion of waves. **Limitation of the demo kit:** In this activity, the students are asked to show the position of the particle at every 1 s interval - the particle in each panel is moved to the next position every 1 s - this may result in the misconception that the particle comes to a stop every 1 s. Thus, there is a need to stress that the particles move in a continuous motion. **Question**: 1. Does the particle come to rest every one second? 2. Ask students to indicate the (two) positions when the particle is momentarily at rest and other (two) positions where it is at equilibrium. **Success Criteria:** ✓ Students able to see the limitations of the demo kit; pauses are introduced at each positions of the motion for learning purpose only. ✓ The particles do not come to rest at every position but rather, they move in continuous motion. ✓ Students are aware that the spacing between the positions are modelled using a generalized wave equation at intervals of unit time. **1.1.1 Plotting the displacement-time graph** 1. Students measure the displacements of the particle in the demo set from the equilibrium position for t = 0 s to t = 12 s and tabulate in the table. 2. Students plot the displacement-time graph using the tabulation. 3. Teacher walks around to facilitate the interpretation of demo kit and the graphical representation. 4. Students present their explanations on the whiteboards for questions on		Activity 1.1: Worksheet 1 Single particle demo kit set per group Whiteboards and markers Table in worksheet 1

TA: Checking for Understanding and Providing Feedback	I. Distance travelled per unit time (spacing between position per unit time) → concept of speed II. Positions where the particle is at its maximum or minimum speed.		
TA: Facilitating Collaborative Learning – Whiteboarding	**1.1.2: Using the concept of speed** Students to • make sense of the data focusing on distances covered per unit time (using the concept of speed) • make use of the average speed at various time intervals to deduce the positions where the particle is at its maximum and minimum speed **Success criteria:** ✓ Students able to apply concept of speed as distance travelled per unit time and use it to understand the motion of a single particle. ✓ Students able to use the average speeds between consecutive intervals to deduce the speed profile of the particle motion, hence able to deduce positions where particle is at mini or max speeds. ✓ Particles in Periodic motion has a cycle that repeats itself. ✓ Students are able to understand that every particle in the rope has the same repeated, periodic motion as that of the oscillating force that drives the wave.		Graph in worksheet 1.2
TA: Facilitating Collaborative Learning	**Activity 1.2** **1.2.1: Using mathematical concepts of gradient of tangents** 1. Students recall what they have learnt in Mathematics on using gradient of tangent to calculate the instantaneous speed. This is an alternative method for interpreting the motion of the particle. 2. Teacher consolidates learning by getting one group to present and use it to check on the students' ability to understand the link between graphical representation and the physical motion of the single particle.		
TA: Checking for Understanding and Providing Feedback	**1.2.2: Extension (Periodic motion of Wave)** The final part of activity 1.2 requires students to plot the displacement-time graph for t = 12 s to t =		

	24 s, this is to bring across the key concept of periodic motion. **Success Criteria:** ✓ Students must be able to use the plotted displacement-time graph of a single particle of the rope to simulate the single particle motion (Deductive approach activating on prior knowledge of kinematics) ✓ Students are able to use alternative method (gradient of tangents) to interpret the motion of the particle. ✓ Students are able to understanding after all particles are set in motion, the periodic motion of every particles and hence the whole wave continue.		
TA: Pacing and Maintaining Momentum- Managing transition from individual particle motion to whole wave motion **TA: Facilitating Collaborative Learning – Whiteboarding** **TA: Exercising Flexibility** **TA: Using Questions to Deepen Understanding**	**2nd C - Construct Understanding** **Activity 2.1** (**Whole Class**) Teacher to ask 13 students each holding on to a demo kit set to simulate the particles motion from t = 0 s at the point when all 13 particles are at their equilibrium position to t = 24 s. Teacher needs to explain the format of this demonstration: 1. There are millions of particles that make up the complete rope. 2. Teacher explains that the 13 consecutive particles chosen is such that after the 1st particle has moved, the 2nd particle will move 1 s later, and so on. (**Groupwork**) Students get into groups of four. Each group will have to capture photos of the set of 13 particles for t = 0 s to t = 12 s. The photos will need to be submitted to teacher through online portal (e.g. Whatsapp, Padlet or Stop-motion) **Ongoing Assessment** Teacher to get two groups to share their particles' motion in a complete wave from t = 0 s to t = 12 s. Teacher to play back the 13 photos that each group captured from t = 0 s to t = 12 s to create an animated wave. **Questions:** 1. How did particle 1 interact with particle 2? 2. How is the energy transfer possible?	20 min 20 min	Activity 2.1: Worksheet Metronome 13 Demo kit set per group

	Activity 2.2 From the simulation panels, measure the distances of particles 1 to 13 from the point of disturbance. Fill in the distances in the boxes provided in the worksheet.		Activity 2.2: Worksheet
TA: Concluding the Lesson **TA: Setting Meaningful Assignments - Using demo kit to show and tell** **TA: Supporting Self-directed Learning**	**3rd C – Consolidate Learning** Students complete a series of questions individually to check on their understanding. There are two extensions questions to consolidate students' learning – students to plot the positions of all particles at t = 24 s and t = 30 s. **Success Criteria:** ✓ Students are able to understand that the oscillating force is the cause of the wave. ✓ All particles in the wave has the same periodic motion as the oscillating force. ✓ The amplitude of the wave remains constant if there is no energy lost. ✓ Students are able to describe how a wave is formed from the time when all particles are at rest to the time when all particles continue their periodic motion. ✓ Students are able to see that all particles are held together by the bonds between them. The bonding allows one particle to link with another, such that the motion of one particle will affect the motion of others linked to it. It is this bonding/link that allows energy to be transferred from one particle to the next. ✓ Students are able to understand the definition of distance on the horizontal axis of displacement-distance graph and demonstrates this understanding by being able to physically measure the distance from the oscillating force at position 1 to the respective equilibrium positions of each particle.	20 min	Activity 2.3: Worksheet Activity 2.4: Worksheet

Reflections:

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