33110 Wave Motion Apparatus

INTRODUCTION: This device permits simple instruction or detailed analysis of traveling wave forms, their amplitudes, frequencies and speeds. Traveling and standing waves, reflection and interference are easily demonstrated.

The waves are created by torsional oscillation of a central member. The natural period of oscillation of this member is regulated by the addition of mass in the form of heavy rods at regular intervals. The added mass slows down the system so that accurate observation of wave form is possible and torsional oscillation of the system is seen as vertical motion at the rod ends.

The device is designed to operate vertically where visibility is a problem or when vertical wave analysis is important. However, in the interest of simplicity, only horizontal demonstrations are described. Vertical counterparts will be readily understood and vertical set-up is described at the end of these instructions.

SINGLE AND MULTIPLE TRAVELING WAVES AND PULSES

Set the device horizontally on a table with rods in a balanced horizontal plane. Either side with its entire row of bright tipped ends, may face class. Grasp the tip of an end rod between thumb and forefinger and give the rod a quick short upward movement. A single wave crest will form and travel to the end of the frame. It will then return (as a crest), repeating until it has dissipated.

The torsion applied to the end rod is propagated for the full length of the system because of the elasticity of the central torsion member. Each rod encountered presents inertia which reduces the speed of the traveling crest. The wave gradually dies out, or dissipates, because of damping factors inherent in any vibrating system. In this case, friction of central torsion member at its suspension points is a major dampening factor, as is the heating of the central member by twisting.
A wave trough or valley may be obtained by imparting a quick downward movement to the end rod. A short, quick movement produces a wave of small amplitude and short length; a short, slow movement produces a wave of small amplitude and long length. A long, slow movement produces a wave of large amplitude and long length. Double and triple waves are obtained by quick repetition of the disturbing force.

Care must be exercised when making long quick movements that produce large amplitude waves of short length, as forces involved may break loose one or more rods at central torsion member. NEVER work rods violently and caution students of this also. The rods should not be worked hard enough to cause clashing with frame.

The bank of inertia rods is delicately balanced in assembly, but may tilt to one side or other when a traveling wave is being observed. Tilting may be overcome by grasping the end rod and leveling the bank of rods while the wave is at the opposite end of the frame. The hand may be removed as the wave approaches and in that way does not interfere with or modify the form.

STATIONARY WAVES

Grasp the end rod and form a traveling wave. Note that if the frequency is properly adjusted, the waves soon add to a standing or stationary wave with nodes or inactive rods at regular intervals. Different modes of standing waves may be sustained by appropriate and regular movement of the end rod.

Stationary waves are caused by the combination of outgoing and returning wave forms. These identical waves are in phase and meet each other while traveling in opposite directions. This produces a stationary wave form identical to traditional text book examples shown with vibrating springs or bars.

REFLECTION CHARACTERISTICS

Grasp the end rod and form a single traveling crest. Note that it reaches the far end and returns as a crest. Now have a student hold the far end rod and start another traveling wave from your end. The wave reaches the far end but returns as a trough. It inverts when it meets the immoveable rod. Inversion is observed when a pulse or wave moves from a region of low impedance to a region of high impedance, that is a region of high wave speed to a region of low wave speed.

The reflected wave acts exactly like a reflected wave in a vibrating spring. If one end of a spring is fixed, a wave form approaching the fixed end will reflect with an opposite contour. If wave form approaches free, or unanchored end of spring, wave reflects without reversal. The instructor may demonstrate these conditions without an assistant by merely holding rod at his end when the wave form returns.

An interesting comparison to a hanging spring may be made by performing these demonstrations with device set up for vertical operation. In this case, the hand should actuate the top rod and remain there to act as an anchored end of spring. The wave will travel to bottom of frame, reflect and return to top where it then reflects with an opposite contour.

REINFORCEMENT AND CANCELLATION

Seat yourself directly behind the wave motion device with the class facing you. Grasp the two end rods lightly between thumb and forefinger of each hand and form a strong wave crest from each end at the same time. The two waves will approach each other and meet at the center rod which is banded for identification. Note that the center rod displaces farther than rods on either side.

The increased amplitude at the point where two waves meet is caused by the combined energies of the two waves, and is the sum of the displacement of the two waves. In the same manner as before, start a strong wave from each end but form a crest with the right hand and a trough with the left hand. The class, of course, sees these waves reversed since it is facing the other side of apparatus. The two waves approach each other and meet at center rod. In this case, the center rod does not move as the two opposite waves cancel out at this point. Note also that the two waves cross each other at center and continue on unaffected by their brief encounter. Careful repetition with waves of different amplitudes will enable class to observe these phenomena clearly.

VERTICAL SET-UP

Stand the device on one end with rod tips facing the class. The device has cushioned feet on one end for this purpose. When demonstrating vertically, it is best to hold the top rod with one hand. This simulates a fixed end of a hanging spring.

STORAGE

The Wave Motion Apparatus is best stored by hanging vertically to a wall. A heavy nail or hook should be provided roughly 6 feet from floor.

CARE AND REPAIR

Although visually pleasing, it is not essential that the row of colored tips be in an exact straight line. Even the smallest wave generated is not affected by inaccuracies of rods when at rest. Therefore, it is recommended that small misalignments be disregarded, as such misalignments may occur in rough handling. However, care should be used when working rods as excessive force may break them loose from central torsion member.

DO NOT attempt to repair rods that have come loose from central torsion member. DO NOT return inertia rod assembly unless original packaging is available. If, due to accident, rough handling, or defects, one or more rods become loose, contact our Customer Service Department for shipping instructions and a suitable shipping container.

Time Allocation:

To prepare this product for an experimental trial should take less than two minutes. Actual experiments will vary with needs of students and the method of instruction, but are easily concluded within one class period.

Feedback:

If you have a question, a comment, or a suggestion that would improve this product, you may call our toll free number.