Wave Interference

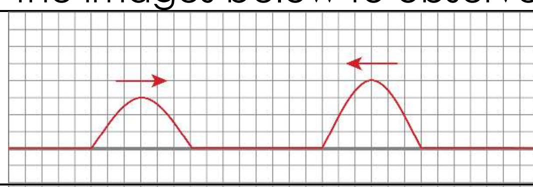
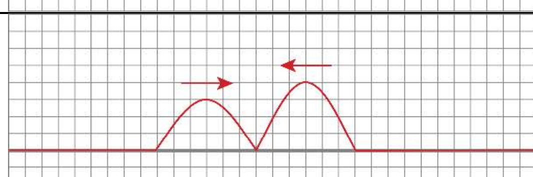
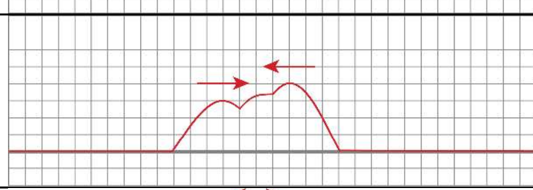
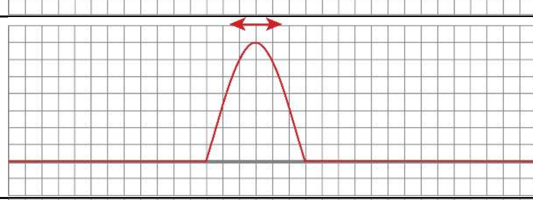
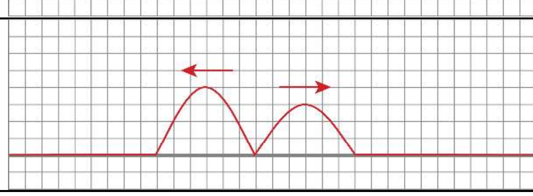
Date: **Name:**

Waves are caused by the vibrations of particles. When multiple vibrations are present, like in the case of water waves affected by the winds, the tides, and boats, the waves interact with one another when they meet. Each vibration affects the motion of the particles by adding up the forces on the particle at that position. The net force on the particle from the different vibrations will determine the position of that particle as the energy flows through it.

The Principle of Superposition

To determine the amplitude of interfering waves, **add** the individual **amplitudes**. In a simple example of only two waves interfering, the resultant amplitude at each point is equal to the **sum** of the amplitudes of the **individual waves** at that point.

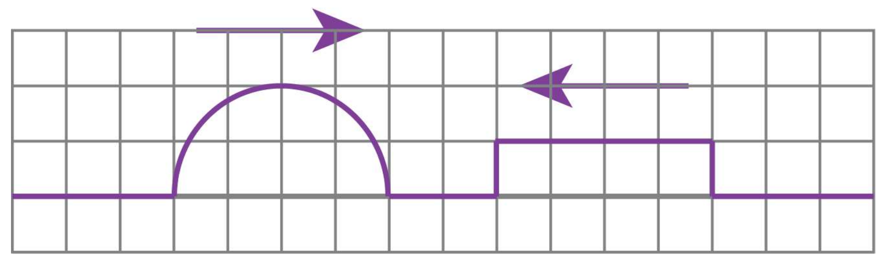
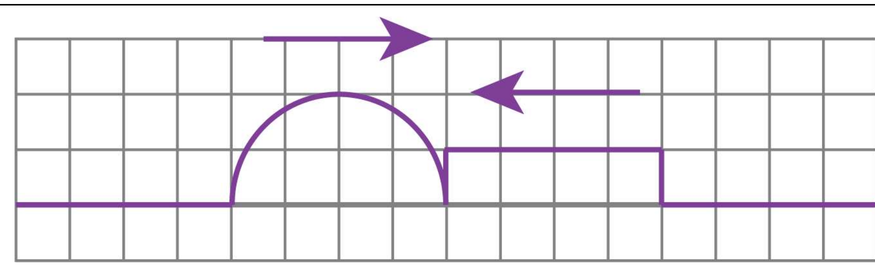
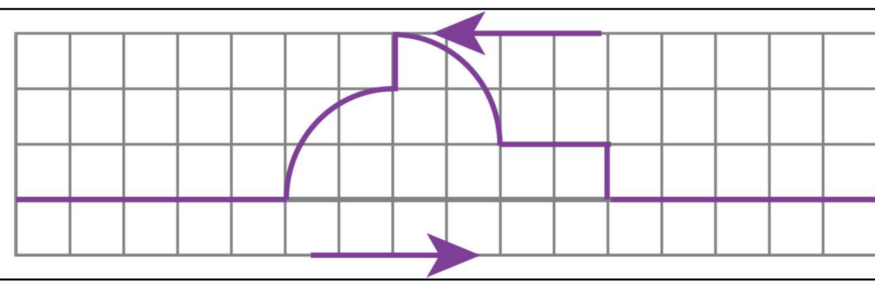
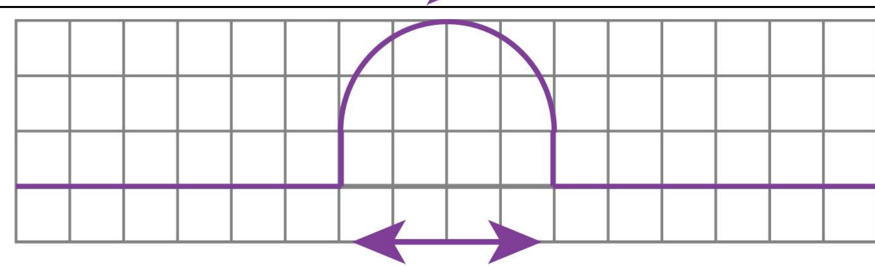
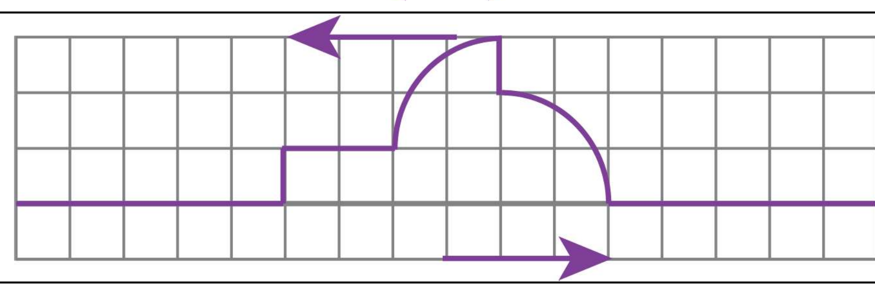
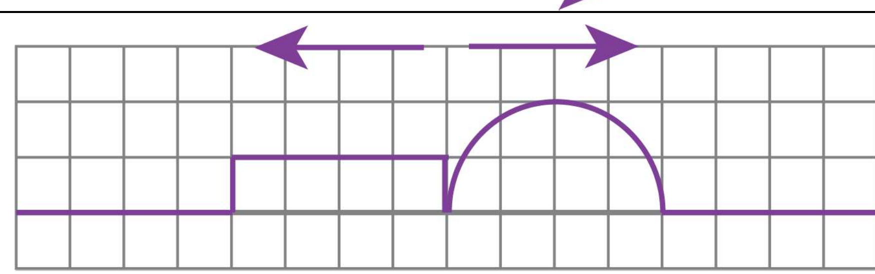
Examine the images below to observe constructive wave interference.

$t = 0\,s$		Two pulses with positive amplitudes are directed toward each other.
$t = 4\,s$		Before the pulses meet their shapes are **unchanged** as they travel through the medium.
$t = 5\,s$		The pulses begin to **interact** in the sections of the medium where they both exist.
$t = 7\,s$		When the pulses overlap, the resultant amplitude **increases** significantly.
$t = 10\,s$		As the pulses continue to move through the medium, they return to their **original shape**.

This type of wave interference is called **constructive interference** since the resultant amplitude is greater than the individual amplitudes.

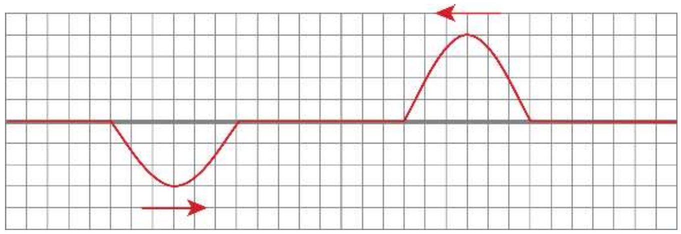
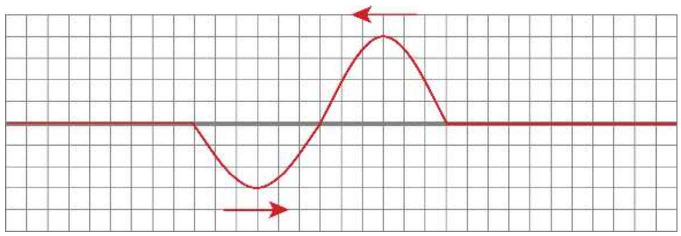
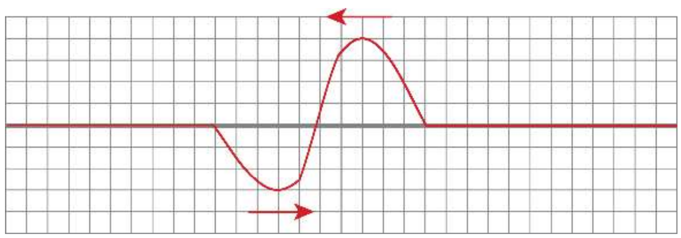
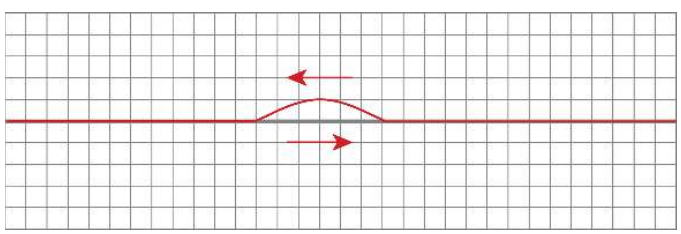
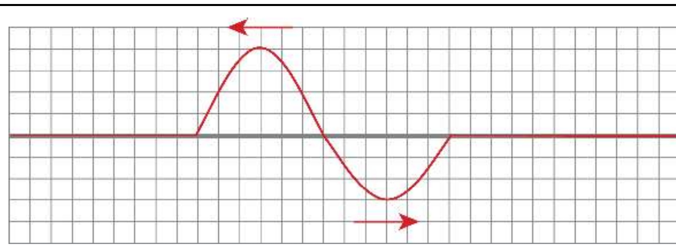
Example 1: Constructive interference

Draw the wave interference of the two pulses as they pass through each other. Each pulse moves one square per second. To determine the resultant amplitude, add the two individual amplitudes together at that point.

$t = 0\,s$	
$t = 1\,s$	
$t = 2\,s$	
$t = 3\,s$	
$t = 4\,s$	
$t = 5\,s$	

Another type of wave interference is called **destructive interference**. Destructive interference occurs when the resultant amplitude is **less than** at least one of the original amplitudes.

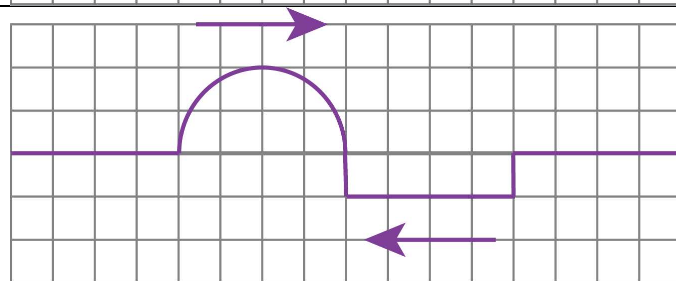
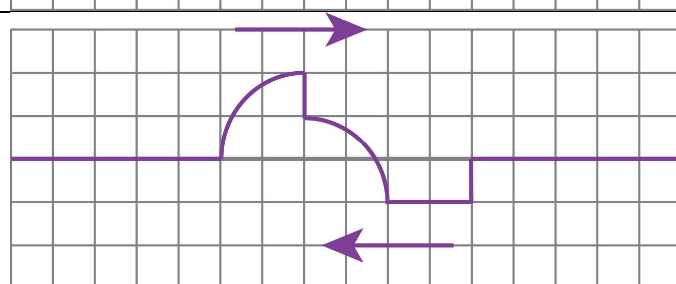
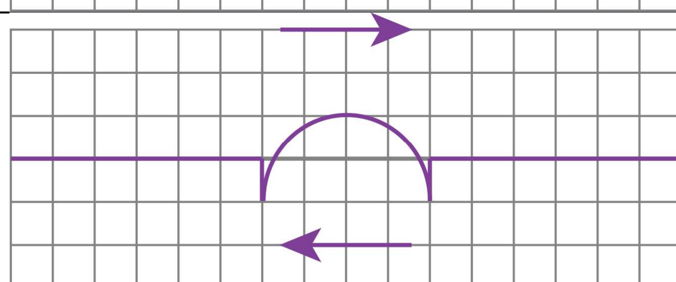
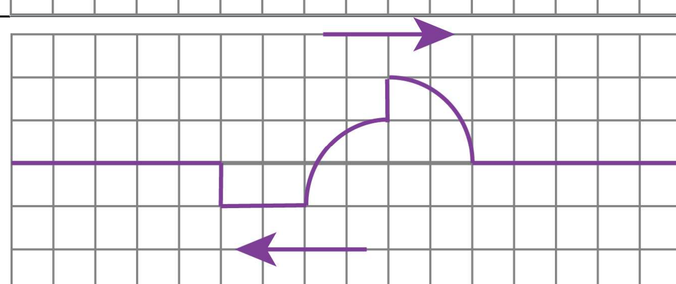
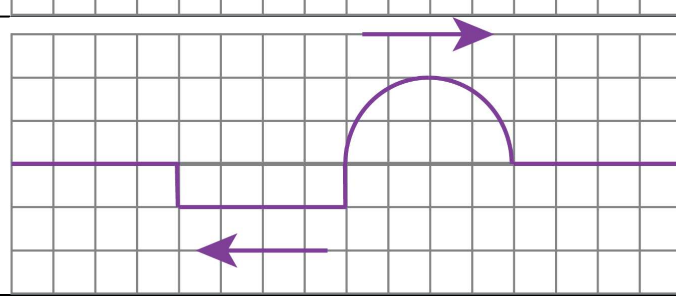
Examine the images below to observe destructive interference.

$t = 0\,s$		Two pulses with opposite amplitudes are directed toward each other.
$t = 4\,s$		Before the pulses meet their shapes are **unchanged** as they travel through the medium.
$t = 5\,s$		The pulses begin to **interact** in the sections of the medium where they both exist.
$t = 7\,s$		When the pulses overlap, their amplitude **decreases** significantly.
$t = 10\,s$		As the pulses continue to move through the medium, they return to their **original shape**.

Note:

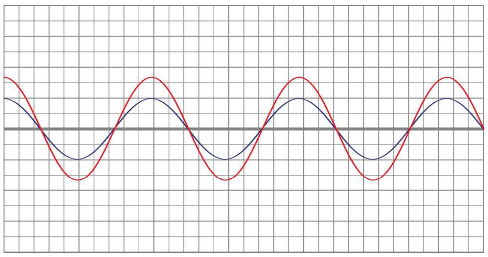
1. The waves do not need to **cancel** each other out completely to be considered destructive interference.
2. The resultant wave's amplitude is the **sum** of the individual waves' amplitudes (which can be a **negative** value).

Example 2:
Draw the wave interference of the two pulses as they pass through each other. Each pulse moves one square per second. To determine the resultant amplitude, add the two individual amplitudes together at that point, keeping in mind that one amplitude is negative.

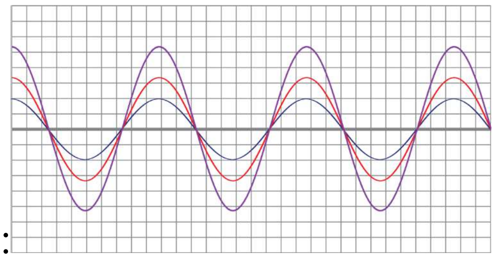
$t = 0\ s$	
$t = 1\ s$	
$t = 2\ s$	
$t = 3\ s$	
$t = 4\ s$	
$t = 5\ s$	

Consider now, periodic waves interacting with one another, not just individual pulses. Depending on the **wavelength**, **period**, and **phase shift** the waves could interact constructively, destructively, or both. Draw the resultant wave by adding the individual amplitudes. Start with key points along the wave.

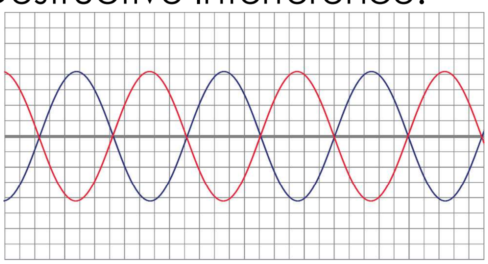
Constructive Interference:



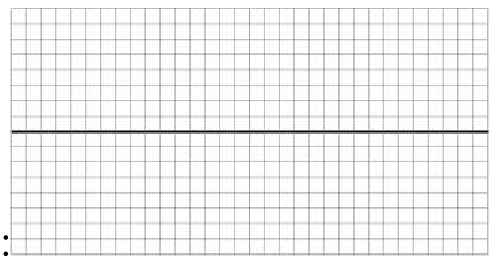
Superposition:



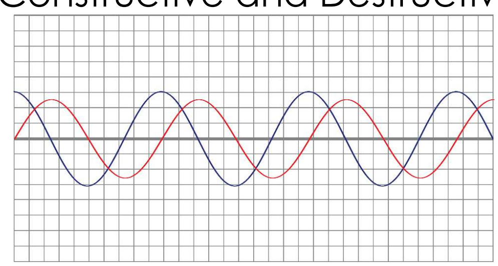
Destructive Interference:



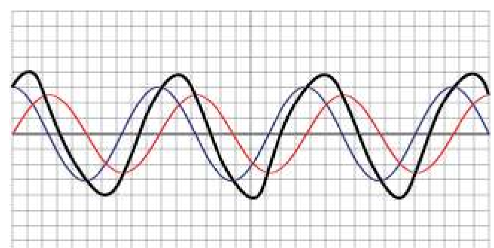
Superposition:



Constructive and Destructive Interference:

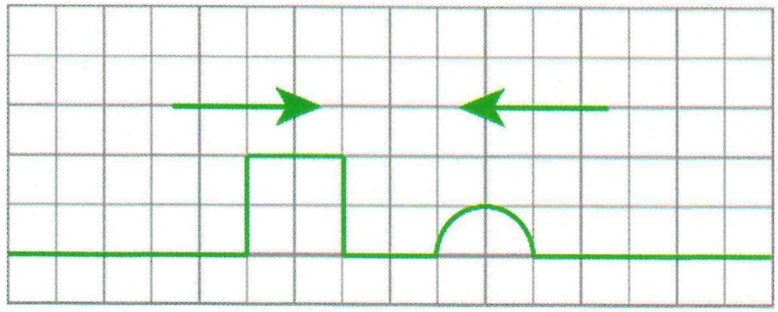
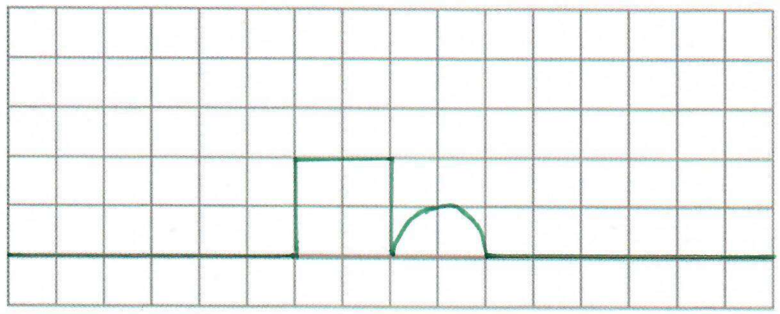
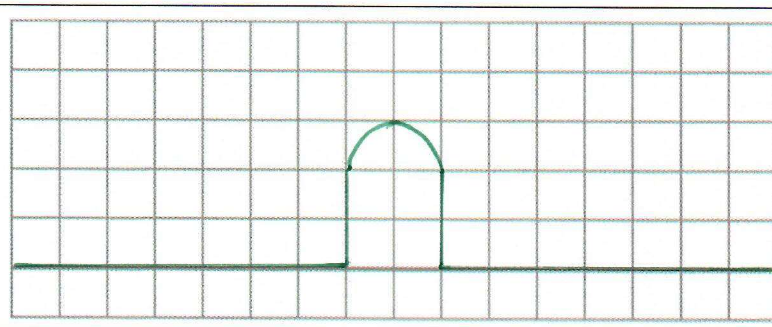
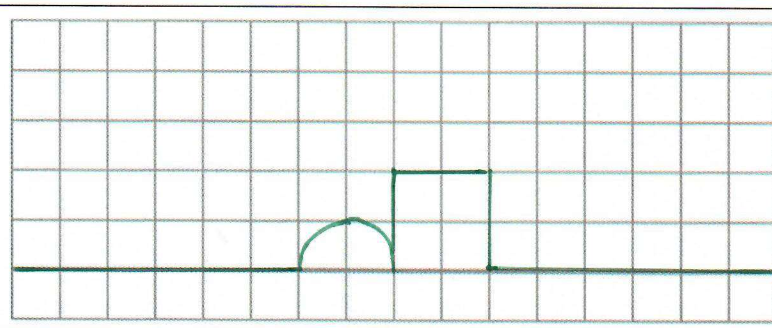


Superposition:



Practice

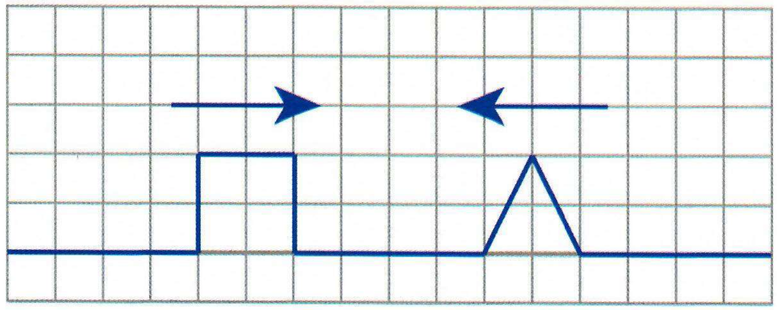
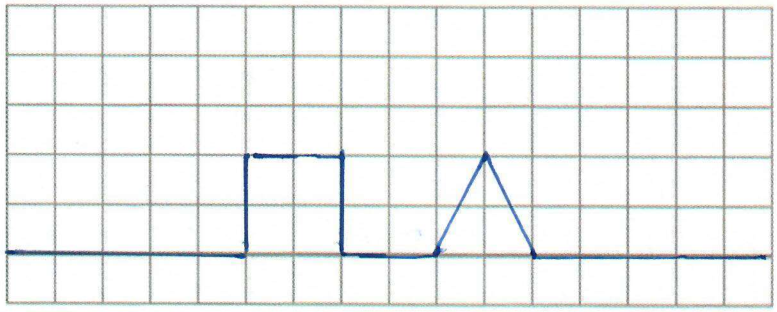
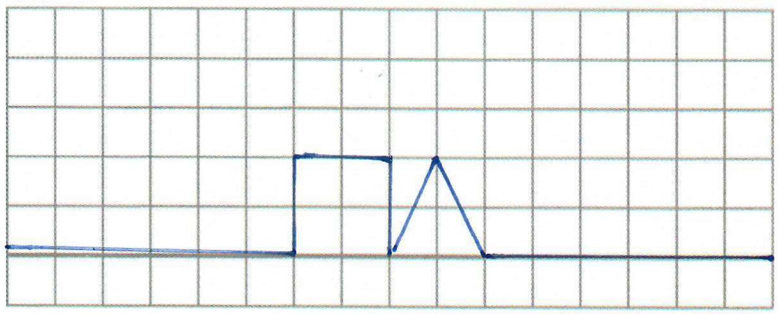
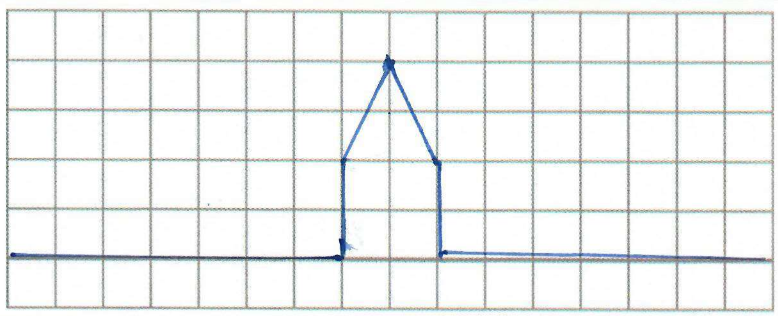
Q1. Draw the wave interference of the two pulses as they pass through each other. Each pulse moves one square per second.

$t = 0\,s$	
$t = 1\,s$	
$t = 2\,s$	
$t = 3\,s$	

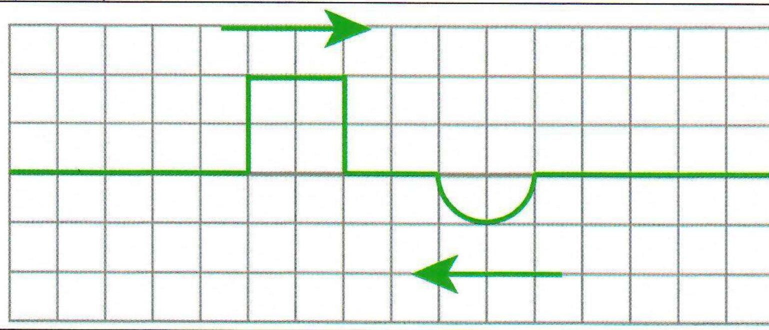
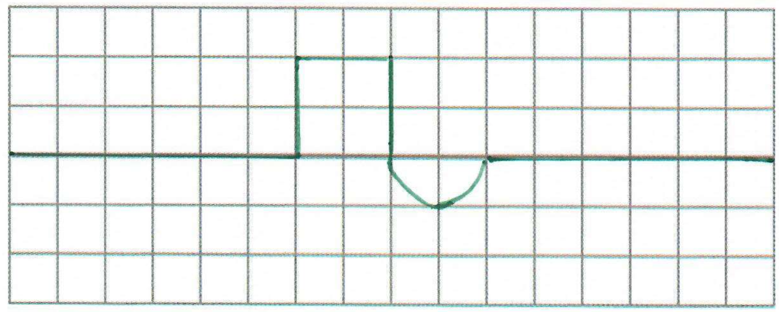
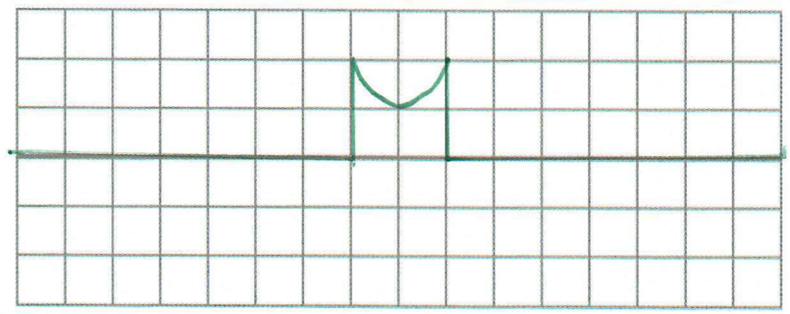
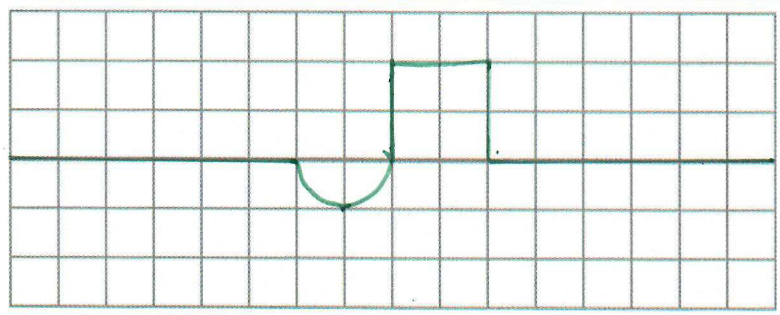
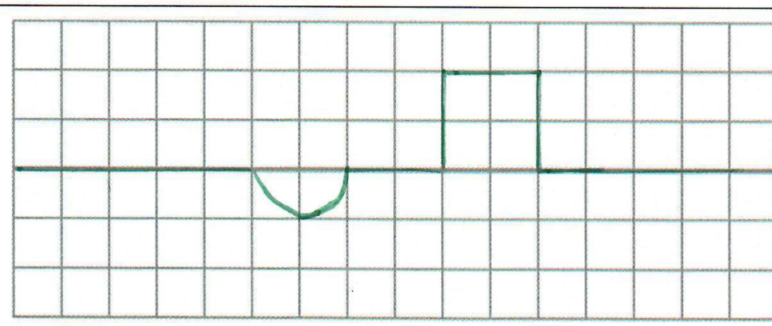
Describe how the pulses interfere with one another.

The pulses pass through one another, keeping their original shape. When the pulses are at the same position, their amplitudes add together.

Q2. Draw the wave interference of the two pulses as they pass through each other. Each pulse moves one square per second.

$t = 0\,s$	
$t = 1\,s$	
$t = 2\,s$	
$t = 3\,s$	
$t = 4\,s$	

Q3. Draw the wave interference of the two pulses as they pass through each other. Each pulse moves one square per second.

$t = 0\,s$	
$t = 1\,s$	
$t = 2\,s$	
$t = 3\,s$	
$t = 4\,s$	

Q4. Draw the resultant wave by adding the individual amplitudes. Start with key points along the wave.