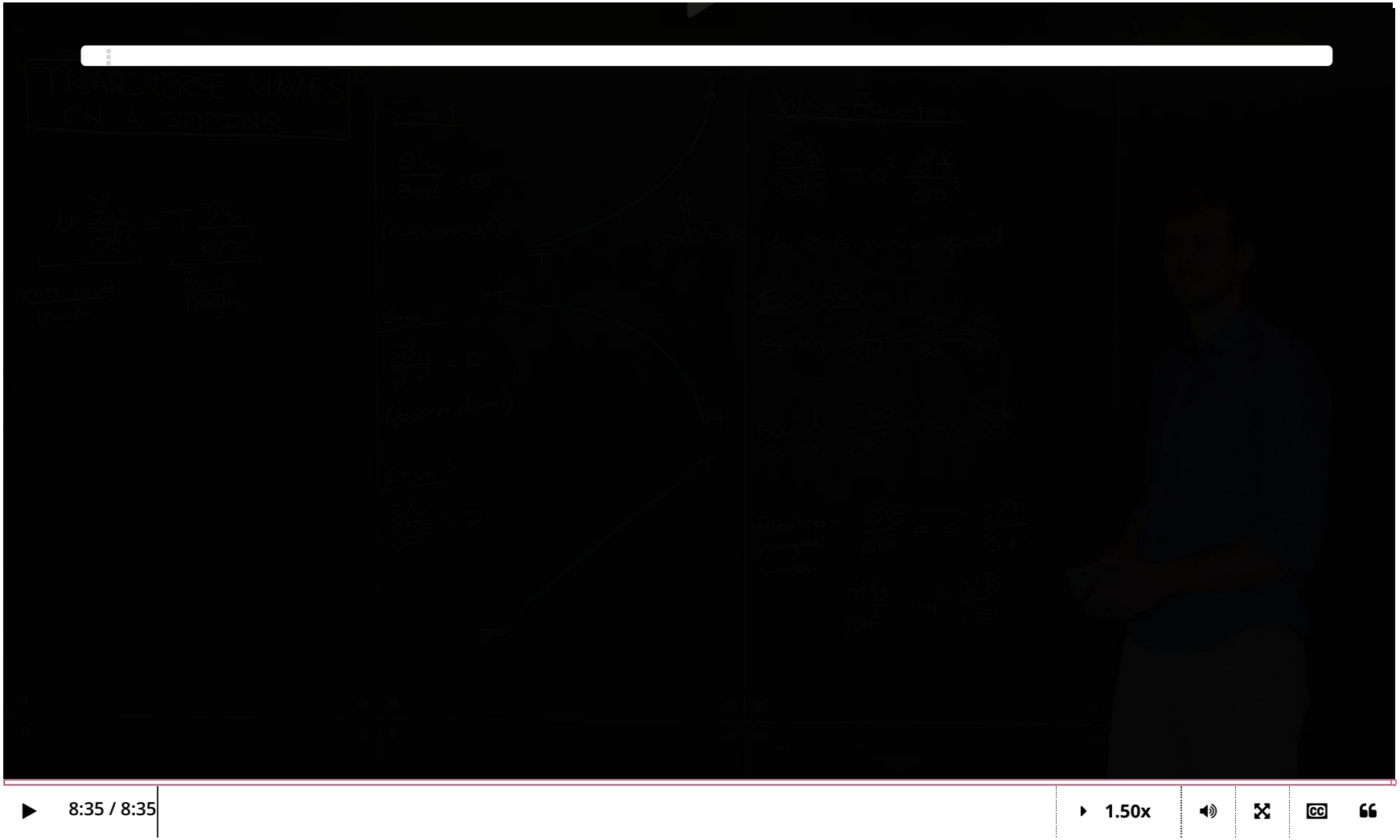
3. Understanding the wave equation
The wave equation in different contexts



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The wave equation is

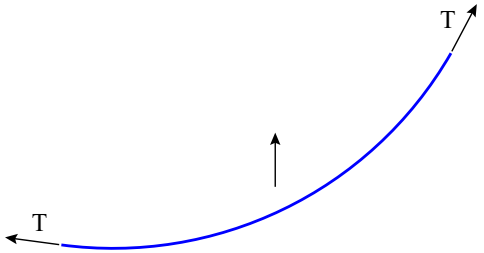
$$\underbrace{\mu \frac{\partial^2 u}{\partial t^2}}_{\text{mass times acceleration / unit length}} = \underbrace{T \frac{\partial^2 u}{\partial x^2}}_{\text{force / unit length}}, \qquad \mu, T > 0$$

where the left hand side describes the mass times acceleration per unit length, and the right hand side is the force per unit length on the string.

Let's think about what this is telling us physically.

Case 1:

Suppose $\frac{\partial^2 u}{\partial x^2} > 0$, that is a small segment of string is concave up.

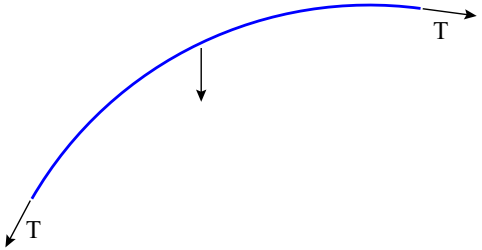


The equation says that the net force is positive, hence the net acceleration is upwards.

This agrees with our expectations that if you imagine pulling on a concave up string along the tension forces, the string will accelerate upwards toward a straight configuration.

Case 2:

Suppose $\frac{\partial^2 u}{\partial x^2} < 0$, that is a small segment of string is concave down.

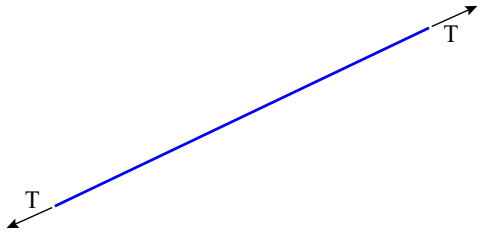


The equation says that the net force is negative, hence the net acceleration is downwards.

This agrees with our expectations that if you imagine pulling on a concave down string along the tension forces, the string will accelerate downwards toward a straight configuration.

Case 3:

Suppose $\frac{\partial^2 u}{\partial x^2} = 0$, that is a small segment of string is straight.



The equation says that the net force is zero, hence the net acceleration is zero.

This agrees with our expectations that if you imagine pulling on a straight segment string along the tension forces, the string will not accelerate at all, and will remain straight.

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