WARNING

This lesson requires the use of a microwave oven, which can pose safety risks when used improperly. Before teaching this lesson, please review the safety precautions in the front matter and the *Teacher Guide* for setting up and running each investigation, as well as for taking down, disposing of, and storing materials.

Slide A

Navigate

With your class

What do the patterns we observed with the nachos suggest about how energy transfers inside the microwave oven?

Navigate

With your class

What did we think was happening in the microwave oven then?

A. Cheese contains more water than chips do.

B. More energy ends up in some places than in others.

C. Every place inside of the oven ends up with the same amount of energy.

Navigate

With your class

- How have we collected data about energy transfer in the microwave oven so far?
- What are the limitations of the current data from the nachos?
- How could we adapt some of these methods to address these limitations?

Slide D

Plan an Investigation

Turn and Talk

- If we put many light bulbs across the microwave oven, what do you think we will see the light bulbs do?
- What safety precautions should be followed for this test?

➔ Be ready to share your ideas with the class.

Plan an Investigation: Safety Guidelines

With your class

Metal in a microwave oven can be very dangerous. We need to take adequate safety precautions.

How can we ensure that...

- ...we include food or liquids that we know will absorb some of the microwave radiation?
- ...metal objects aren't within 1 inch of the walls, floor, or ceiling of the oven?
- ...objects inside do not reach dangerous temperatures?

Collect New Data

With your class

We will develop models for explaining the patterns in the cheese and the light bulbs.

- Observe the small light bulbs while the microwave oven is running.
- Record your observations of any patterns in your science notebook.

Develop a Model to Explain Patterns

With your group

Develop a model, using words and drawings, to explain the patterns in the cheese and the small light bulbs.

Gallery Walk

With your class

- Add check marks to places of the model that agree with our understanding.
- Add questions on sticky notes to places where the model does not yet explain the patterns we observed.

Observe Patterns of Wave Motion

With your class

As you watch the wave pulses interact:

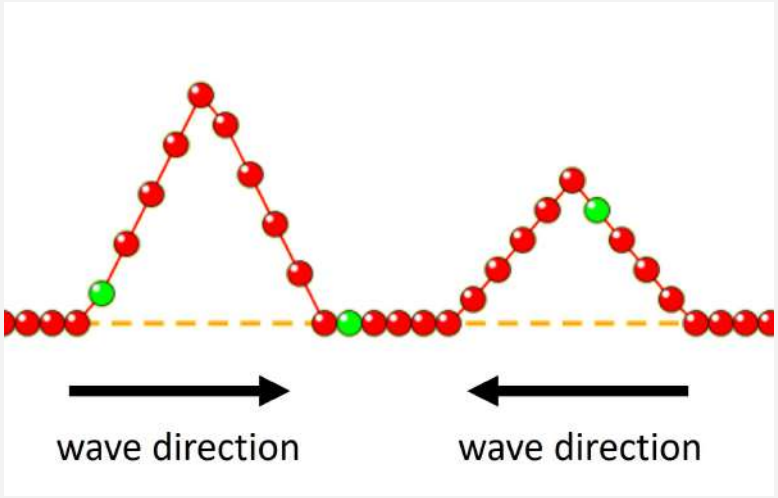
- What do you notice?
- What do you wonder?

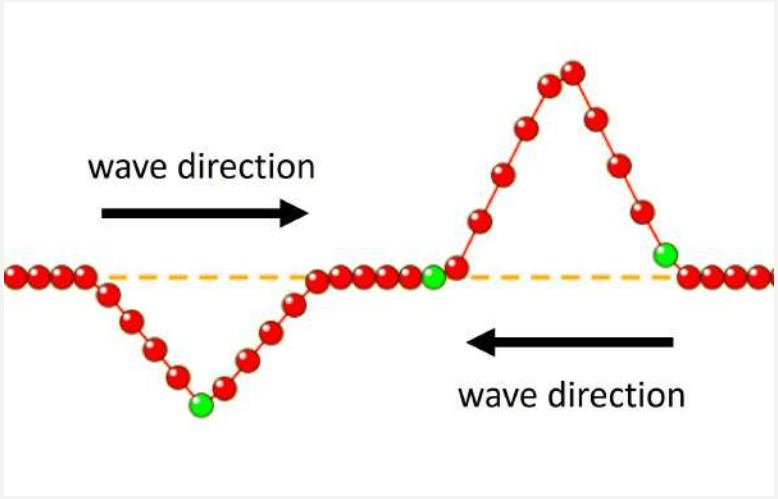
➔ Be ready to share your ideas with the class.

Explain Wave Interference

On your own

Answer the prompts for Interactions A and B on the handout to explain what is happening.



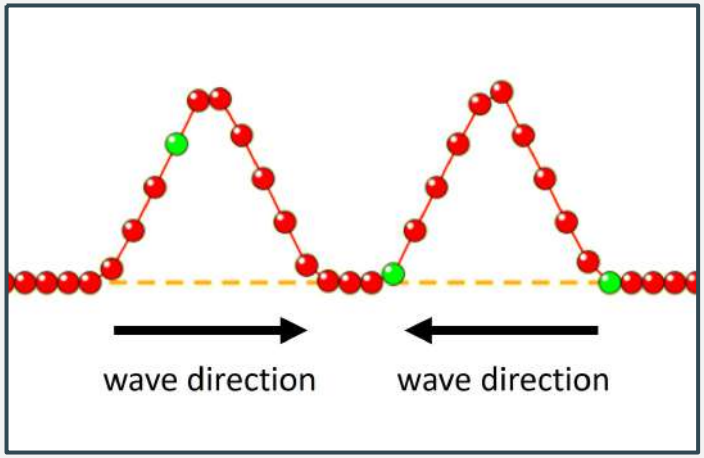


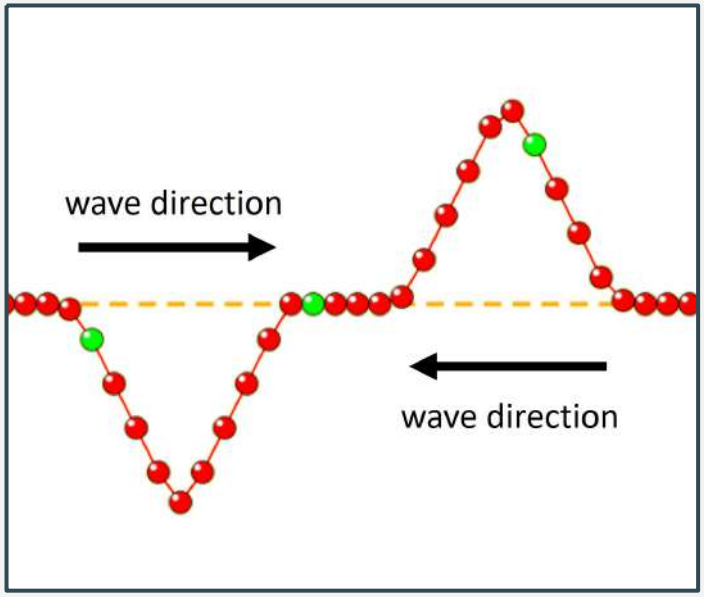
Adapted from: PhET Interactive Simulations

Navigate with Predictions

On your own

Answer the prompts for Interactions C and D on the handout to predict what would happen.





Adapted from: PhET Interactive Simulations

Navigate

Turn and Talk

Compare your predictions with a partner.

- How do your predictions about the changes in matter compare?

With your class

Observe the simulation to see if it matches your prediction.

Explain Wave Interference

With your partner

- What pattern do we see with how the matter of the waves behaves?
- What happens to the total energy in the system?
- How do the forces acting on the string particles help explain the outcome when they meet?

➔ Be ready to share your ideas with the class.

Explain Wave Interference

With your class

Can our reasoning about matter, forces, and energy here help to explain the hot and cold spots we observed in the microwave oven?

Add to Your Personal Glossary

In your notebook

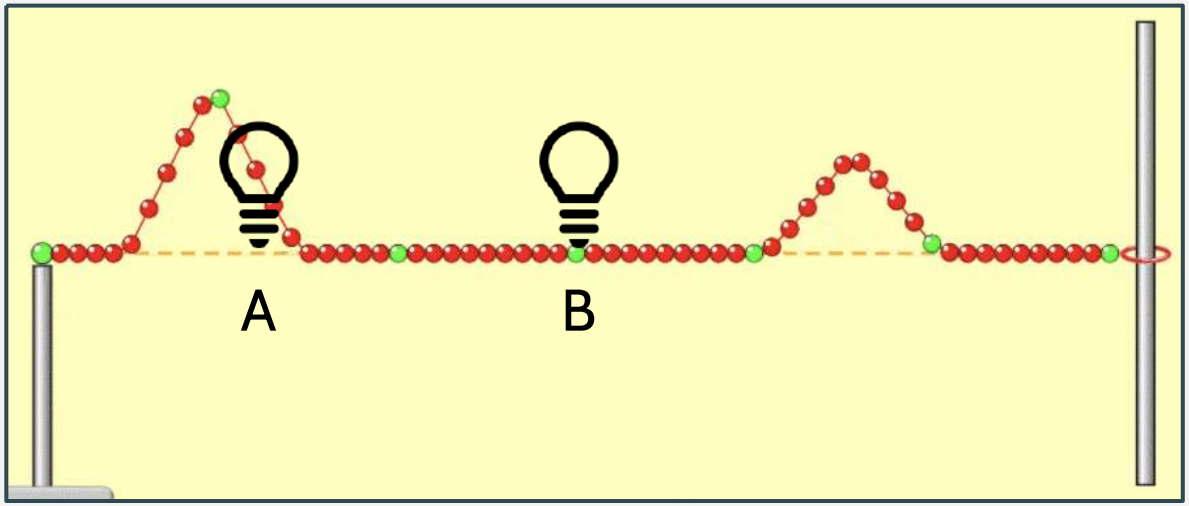
Write definitions for the following terms in your Personal Glossary:

- *interference*
- *constructive interference*
- *destructive interference*

Consider Limitations of the Simulation

With your class

- How would light bulbs behave if these waves were transferring energy to them?
- Does this match what we saw in the microwave oven?

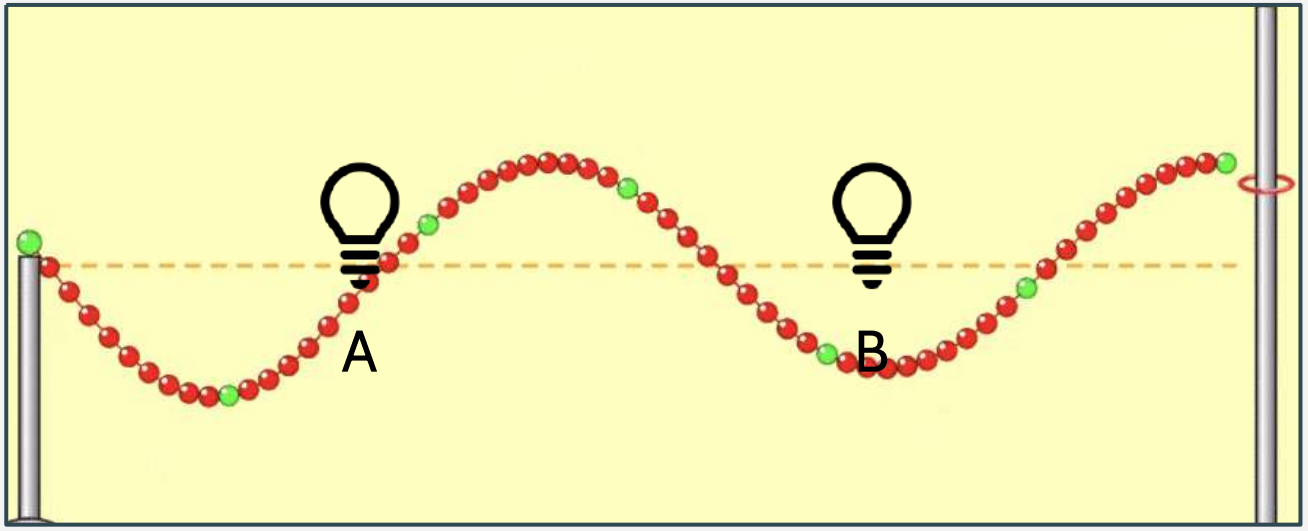


Adapted from: PhET Interactive Simulations

Observe Continuous Wave Interference

With your class

- What patterns do we observe?
- How does this help explain the hot and cold spots in the microwave oven?



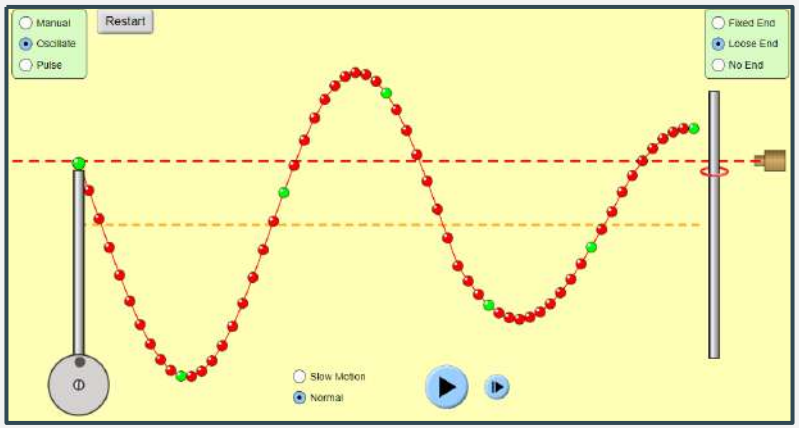
Adapted from: PhET Interactive Simulations

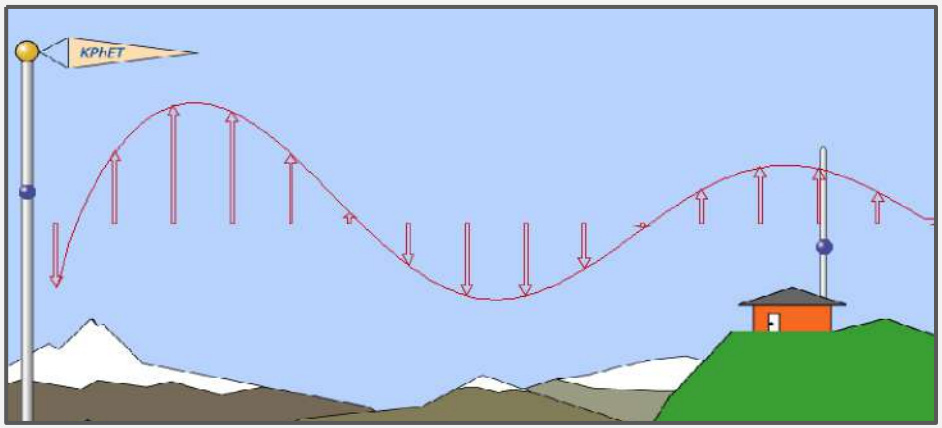
Compare Wave Models

Turn and Talk

- How do electromagnetic waves compare to those in the string?
- What do the arrows represent?
- What would happen when 2 electromagnetic waves pass through the same place in space?

➔Be ready to share your ideas.





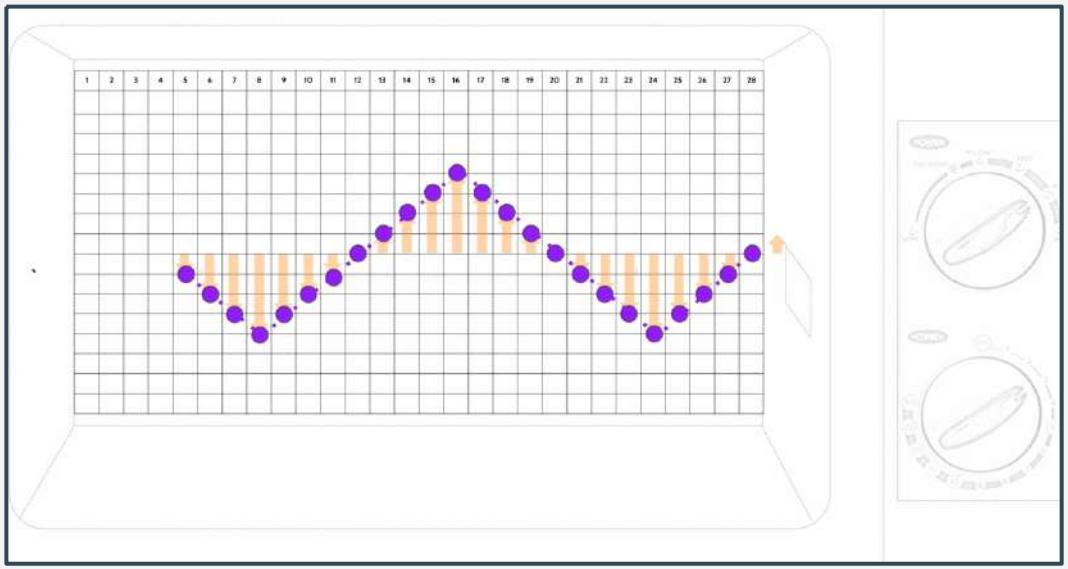
PhET Interactive Simulations

Explore Wave Interactions

With your class

This is a 2-D model of the microwave oven.

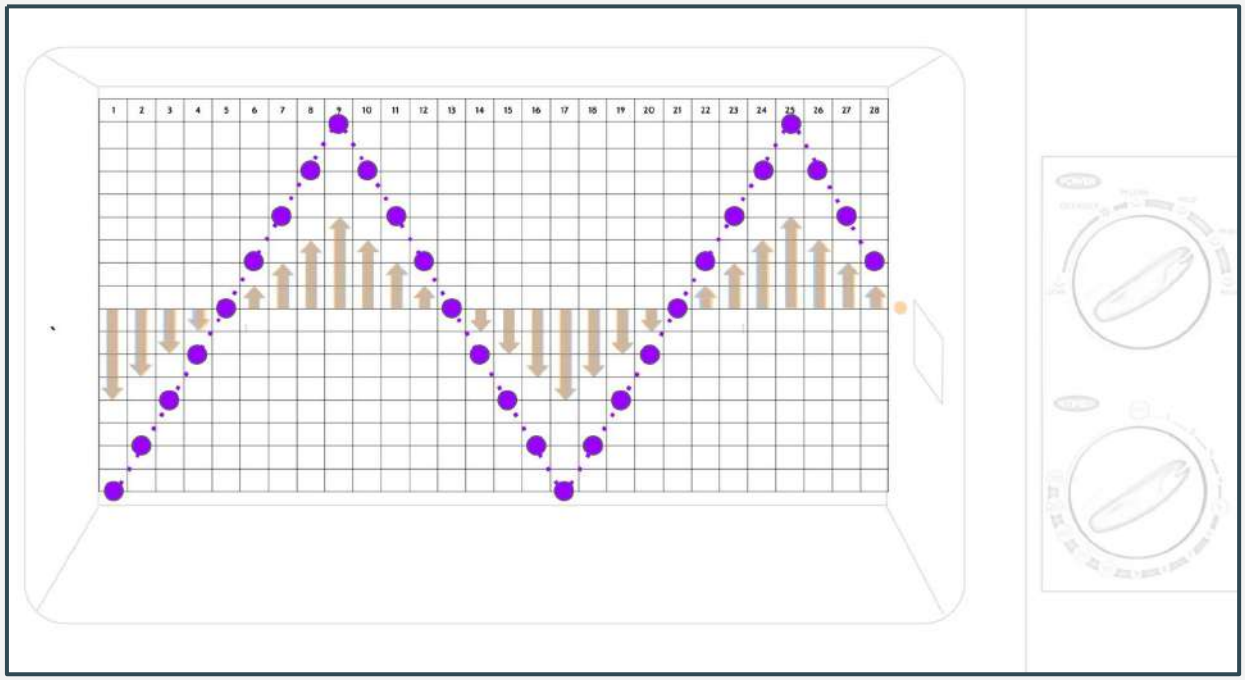
- What do the arrows represent?
- What do the wave colors represent?
- What do the dots represent?



Explore Wave Interactions

With your group

- Where would the cold spots be located?
- Where would the hot spots be located?



Revise Our Models to Explain Patterns

With your group

Revise your model, using words and drawings, to explain the patterns in the cheese and the small light bulbs.

Be sure to include details about matter, energy, and forces in your model.

Synthesize Ideas about Wave Interference

In your notebook

Update your Progress Tracker with your updated model to explain the patterns in the microwave oven.

Progress Tracker

Lesson #	What patterns or results did we see or experience that helped us figure something out ?	What caused these patterns or results?	How does this help us further our models or answer our questions on the DQB?

Make Predictions with Your Partner's Model

Turn and Talk

If we put the light bulbs on the turntable and run the microwave oven, what do you predict will happen?

➔ Be ready to share your ideas with the class.

Plan an Investigation: Safety Guidelines

With your class

Metal in a microwave oven can be very dangerous. We need to take adequate safety precautions.

How can we ensure that...

- ...we include food or liquids that we know will absorb some of the microwave radiation?
- ...metal objects aren't within 1 inch of the walls, floor, or ceiling of the oven?
- ...objects inside do not reach dangerous temperatures?

Slide Y

Investigate the Turntable with Light Bulbs

Individual Think Time

As the microwave oven runs with the small bulbs on the turntable:

- How do your observations compare to your model and your partner's predictions?
- What do your observations suggest about the role of the turntable in energy
the microwave ove

→ Be ready to share your ideas with the class.

Revise the Consensus Model from the Anchor

Scientists Circle

Let's revise our initial consensus model to explain:

1. how the microwave oven heats food/liquid
2. why the music was affected when the wireless device was inside the microwave oven, especially when the speaker was farther away

Return to the DQB

Individual Think Time

- What are the limitations of our updated consensus model?
- What questions does our model still not answer?

➔ Be ready to share your ideas with the class.

Return to the DQB

On your own

Review the questions on our Driving Question Board and add a sticky dot to a question that you think:

- Green: we can answer
- Yellow: we can partially answer
- Red: we cannot answer at all

➔ Be ready to share your ideas with the class.

Return to the DQB

Scientists Circle

- What strategies have allowed us to explore the questions we can answer now?
- What do the questions we cannot answer have in common?
- What new related phenomena can we explain, or have new questions about?

Return to the DQB

Scientists Circle

What new questions do we have about microwave radiation or related phenomena?

- *Write 1 question per sticky note.*
- *Write in marker-- big and bold.*
- *Put your initials on the back in pencil.*

Complete an Electronic Exit Ticket

On your own

Use a computer to complete the Electronic Exit Ticket.

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