Update to Content Accepted by SRP

Request to Update Content Reviewed and Accepted by the State Review Panel (SRP)
Proposed changes shall be made available for public review on Texas Education Agency's website for a minimum of seven calendar days prior to approval.

Indicate if the changes in the content were reviewed and accepted by the SRP to determine coverage of the Texas Essential Knowledge and Skills (TEKS), English Language Proficiency Standards (ELPS), or Texas Prekindergarten Guidelines (TPG) by selecting a box below. (**Note**: All request to update editions that do not change content reviewed and accepted by the SRP must be entered on the *Update to Content Not Reviewed by SRP* document.)

☒ TEKS ☐ELPS ☐TPG ☐TEKS and ELPS

Proclamation Year: 2024
Publisher: PASCO scientific
Subject Area/Course: Science/ Physics

Adopted Program Information:

Title: Essential Physics 3rd Edition
ISBN: 978-1-937492-13-7

Adopted Component Information

Title: Essential Physics 3rd Edition: Teacher Resources
ISBN: 978-1-937492-19-9

Publisher's overall rationale for this update

Enter the primary reason for the update request.

PASCO received a score of 91.49% in relation to our TEKS correlations during the SRP for the Essential Physics 3rd Edition curriculum. PASCO wishes to increase our correlation score to 100% to ensure we are supporting Texas teachers and students to the best of their abilities and by fully supporting the state mandated standards.

Publisher's overall description of the change

Enter an overall description of the change(s).

PASCO proposes updates to 10 breakouts that were rejected during the SRP. Many changes were minor and included text additions of exact wording that was in the TEKS to ensure clarity of the content such as, directly mentioning scientists by name (Malus's Law/Heisenberg). Additional narratives and activities have been created to strengthen student expectations related to Heisenberg's Uncertainty Principle.

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Access Information

Enter access information below to the adopted version of the instructional materials and the proposed new content.

Currently Adopted Content URL: https://education.pasco.com
Currently Adopted Content Username: n/a
Currently Adopted Content Password: Access code: TEKS-EP3-TE-0724-669A4

Proposed Updated Content URL:
Texas Updated EP3 TEKS additions:
https://drive.google.com/drive/u/1/folders/1xG4hufKJpap9rWUlslmUt0zA2KpNcmMs
Proposed Updated Content Username: n/a
Proposed Updated Content Password: n/a

Update comparison:

Each change in the component on this form should be documented in the update comparison below. You must submit a separate request for **each component**, not each change. (**Note**: Repeat this section as often as needed by copying and pasting the entire area from the (SE)(Breakout(s)) and (Citation Type(s)) to the dividing line for each change.)

(SE)(Breakout(s)) and (Citation Type(s))
(2)(A)(i), Falls under both Narrative and Activity

Description of the specific location and hyperlink to the exact location of currently adopted content
Page 54, Lesson 3 Resources, left sidebar, Graphing Data Lesson Plan, Slide Presentation
https://education.pasco.com/epub/Physics/eBook-SBTE/BookInd-714.html

Description of the specific location and hyperlink to the exact location of the proposed new content
Page 54, Lesson 3 Resources, left sidebar, Graphing Data Lesson Plan, Slide Presentation
New content will be placed in the original locations noted under current content.
https://drive.google.com/drive/u/1/folders/1xG4hufKJpap9rWUlslmUt0zA2KpNcmMs

Screenshot of Currently Adopted Content

Insert a screenshot of your currently adopted content.

Chapter 2, section 2.3, page 54 lesson plan:
Lesson plan current:

This lesson focuses on the skills needed to create and interpret graphs of experimental data. Emphasis is placed on the use of consistent units and careful attention to the scale used on x- and y-axes. Students learn to distinguish among the relationships between variables (such as linear, inverse, non-linear), and learn to match these mathematical models to data using an interactive graphing simulation.

Update to Content Accepted by SRP

Learning objectives

The student will be able to:

1) convert quantities from one unit to another using appropriate *conversion factors;*
2) identify the *independent* and *dependent variables* in an experiment;
3) evaluate data and make inferences from data represented graphically, and communicate valid conclusions supported by the data; and
4) express and manipulate relationships among physical variables quantitatively using equations and graphs.

Lesson plan segments

- Brainstorming session: Ask students to brainstorm, with a partner, a variety of ways that quantitative experimental findings can be communicated. Gather their responses to make a list on the board.

- Slide presentation: The presentation provides guided practice in converting quantities using conversion factors. It describes how to identify the independent and dependent variables in an experiment and the importance of referring to the scales on the *x*- and *y*-axes when analyzing data in graphs. It illustrates the differences among scatter plots, linear, inverse, and non-linear graphs.

Crosscutting concepts	Patterns	Cause and Effect	Systems and Models	Energy and Matter	Structure and Function	Stability and Change	Scale, Proportion, Quantity

- Patterns in experimental data sets can be inferred using graphs.
- The scale of a graph must be considered when evaluating the data depicted.

Screenshot of Proposed New Content

Insert a screenshot of your proposed new content.

Chapter 2, section 2.3, page 54 lesson plan:

This lesson focuses on the skills needed to create and interpret graphs of experimental data. Emphasis is placed on the use of consistent units and careful attention to the scale used on *x*- and *y*-axes. Students learn to distinguish among the relationships between variables (such as linear, inverse, non-linear), and learn to match these mathematical models to data using an interactive graphing simulation. Students learn to evaluate these models for their advantages and limitations.

Learning objectives

The student will be able to:

1) convert quantities from one unit to another using appropriate *conversion factors;*
2) identify the *independent* and *dependent variables* in an experiment;
3) evaluate data and make inferences from data represented graphically, and communicate valid conclusions supported by the data;
4) express and manipulate relationships among physical variables quantitatively using equations and graphs; and
5) identify advantages and limitations of models.

Lesson plan segments

- Brainstorming session: Ask students to brainstorm, with a partner, a variety of ways that quantitative experimental findings can be communicated. Gather their responses to make a list on the board.

- Slide presentation: The presentation provides guided practice in converting quantities using conversion factors. It describes how to identify the independent and dependent variables in an experiment and the importance of referring to the scales on the *x*- and *y*-axes when analyzing data in graphs. It identifies advantages and limitations of models. It illustrates the differences among scatter plots, linear, inverse, and non-linear graphs.

Update to Content Accepted by SRP

answer: 60 g

Objective 5: A student made the mathematical model for the dropped marble: $v = 4.4\sqrt{h}$ to describe the relationship between the final speed v and the initial height h. What are some advantages of this model and what are its limitations?

answer: The advantages of the model are its predictive powers as it helps us forecast object motion easily. And the conceptual clarity, as it shows a clear height-speed relationship. One limitation is the assumption that all objects fall like marbles on Earth and it therefore may not work for light objects or on planets with different gravity. The model is also idealized, as it excludes air resistance, unlike real-world conditions.

Crosscutting concepts	Patterns	Cause and Effect	Systems and Models	Energy and Matter	Structure and Function	Stability and Change	Scale, Proportion, Quantity
	• Patterns in experimental data sets can be inferred using graphs. • Identifying both the advantages and limitations of models is essential when assessing their practicality. • The scale of a graph must be considered when evaluating the data depicted.						

Chapter 2, section 2.3, page 54 Slide Presentation Proposed: Slides 2, 6,31,32,33,49,50

Slide 2

Objectives

- **Convert quantities from one unit to another using appropriate *conversion factors.***
- **Identify the *independent* and *dependent variables* in an experiment.**
- **Evaluate and make inferences from data represented graphically, and communicate valid conclusions supported by the data.**
- **Identify advantages and limitations of system models**
- **Express and manipulate relationships among physical variables quantitatively using graphs.**

Slide 6

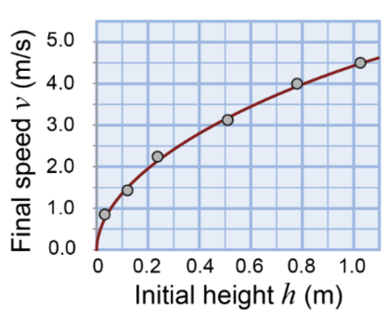
Assessment

4. A student made the mathematical model:

$$v = 4.4\sqrt{h}$$

to describe the relationship between the Final speed v and the Initial height h.

What are some advantages of this model and what are its limitations?



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Slide 30

Evaluating Models

Like any tool, models have both advantages and limitations. Some advantages are:

- Simplification- Models make complex ideas easier to understand
- Predictive Power-help make accurate prediction about future behaviors
- Conceptual understanding- Models provide a framework for understanding the physical world

Slide 32

Test your knowledge

The equation for speed is: $speed = \frac{d}{t}$

What are advantages of this model?

What are limitations of this model?

Slide 33

Test your knowledge

The equation for speed is: $speed = \frac{d}{t}$

What are advantages of this model?

Simple way to accurately predict or calculate speed.

What are limitations of this model?

It's incomplete and only accurate when there is no change in speed or direction.

Slide 49

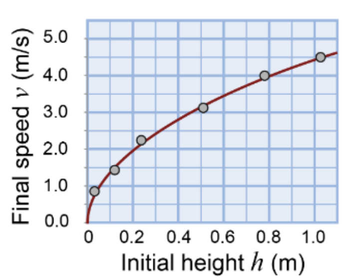
Assessment

4. A student made the mathematical model for the dropped marble:

$$v = 4.4\sqrt{h}$$

to describe the relationship between the final speed v and the initial height h.

What are some advantages of this model and what are its limitations?



Slide 50

Update to Content Accepted by SRP

advantages

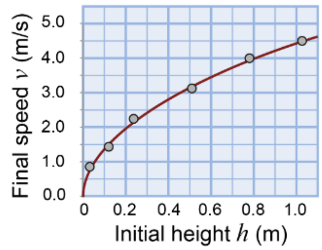
Assessment

4. A student made the mathematical model for the dropped marble:

$$v = 4.4\sqrt{h}$$

to describe the relationship between the final speed v and the initial height h.

What are some advantages of this model and what are its limitations?



The **advantages** of the model are it's **predictive powers** as it helps us forecast object motion easily. And the **conceptual clarity,** as it shows a clear height-speed relationship. One **limitation** is the **assumption** that all objects fall like marbles on Earth and it therefore may not work for light objects or on planets with different gravity. The model is also **idealized**, as it excludes air resistance, unlike real-world conditions.

(SE)(Breakout(s)) and (Citation Type(s))
(2)(A)(ii), Activity

Description of the specific location and hyperlink to the exact location of currently adopted content
Page 54, Lesson 3 Resources, left sidebar, Graphing Data Lesson Plan, Slide Presentation
https://education.pasco.com/epub/Physics/eBook-SBTE/BookInd-714.html

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https://drive.google.com/drive/u/1/folders/1xG4hufKJpap9rWUlslmUt0zA2KpNcmMs

Screenshot of Currently Adopted Content

Insert a screenshot of your currently adopted content.

Update to Content Accepted by SRP

Chapter 2, section 2.3, page 54 lesson plan:

Lesson plan current:

This lesson focuses on the skills needed to create and interpret graphs of experimental data. Emphasis is placed on the use of consistent units and careful attention to the scale used on *x*- and *y*-axes. Students learn to distinguish among the relationships between variables (such as linear, inverse, non-linear), and learn to match these mathematical models to data using an interactive graphing simulation.

Learning objectives

The student will be able to:

1) convert quantities from one unit to another using appropriate *conversion factors;*
2) identify the *independent* and *dependent variables* in an experiment;
3) evaluate data and make inferences from data represented graphically, and communicate valid conclusions supported by the data; and
4) express and manipulate relationships among physical variables quantitatively using equations and graphs.

Lesson plan segments

- Brainstorming session: Ask students to brainstorm, with a partner, a variety of ways that quantitative experimental findings can be communicated. Gather their responses to make a list on the board.
- Slide presentation: The presentation provides guided practice in converting quantities using conversion factors. It describes how to identify the independent and dependent variables in an experiment and the importance of referring to the scales on the *x*- and *y*-axes when analyzing data in graphs. It illustrates the differences among scatter plots, linear, inverse, and non-linear graphs.

Crosscutting concepts	Patterns	Cause and Effect	Systems and Models	Energy and Matter	Structure and Function	Stability and Change	Scale, Proportion, Quantity

- Patterns in experimental data sets can be inferred using graphs.
- The scale of a graph must be considered when evaluating the data depicted.

Screenshot of Proposed New Content

Insert a screenshot of your proposed new content.

Lesson plan proposed:

Content

This lesson focuses on the skills needed to create and interpret graphs of experimental data. Emphasis is placed on the use of consistent units and careful attention to the scale used on *x*- and *y*-axes. Students learn to distinguish among the relationships between variables (such as linear, inverse, non-linear), and learn to match these mathematical models to data using an interactive graphing simulation. Students learn to evaluate these models for their advantages and limitations.

Update to Content Accepted by SRP

Learning objectives

The student will be able to:

1) convert quantities from one unit to another using appropriate *conversion factors;*
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3) evaluate data and make inferences from data represented graphically, and communicate valid conclusions supported by the data;
4) express and manipulate relationships among physical variables quantitatively using equations and graphs; and
5) identify advantages and limitations of models.

- Slide presentation: The presentation provides guided practice in converting quantities using conversion factors. It describes how to identify the independent and dependent variables in an experiment and the importance of referring to the scales on the *x*- and *y*-axes when analyzing data in graphs. It identifies advantages and limitations of models. It illustrates the differences among scatter plots, linear, inverse, and non-linear graphs.

Objective 5: A student made the mathematical model for the dropped marble: $v = 4.4\sqrt{h}$ to describe the relationship between the final speed *v* and the initial height *h*. What are some advantages of this model and what are its limitations?

answer: The advantages of the model are its predictive powers as it helps us forecast object motion easily. And the conceptual clarity, as it shows a clear height-speed relationship. One limitation is the assumption that all objects fall like marbles on Earth and it therefore may not work for light objects or on planets with different gravity. The model is also idealized, as it excludes air resistance, unlike real-world conditions.

Crosscutting concepts	Patterns	Cause and Effect	Systems and Models	Energy and Matter	Structure and Function	Stability and Change	Scale, Proportion, Quantity

- Patterns in experimental data sets can be inferred using graphs.
- Identifying both the advantages and limitations of models is essential when assessing their practicality.
- The scale of a graph must be considered when evaluating the data depicted.

Proposed Slide Presentation Content: Slides 2,6,30,31,32,33,49,50

Slide 2

Update to Content Accepted by SRP

Objectives

- Convert quantities from one unit to another using appropriate *conversion factors.*
- Identify the *independent* and *dependent variables* in an experiment.
- Evaluate and make inferences from data represented graphically, and communicate valid conclusions supported by the data.
- Identify advantages and limitations of system models
- Express and manipulate relationships among physical variables quantitatively using graphs.

Slide 6

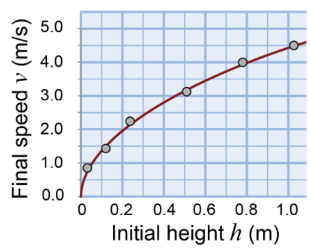
Assessment

4. A student made the mathematical model for the dropped marble:

$$v = 4.4\sqrt{h}$$

to describe the relationship between the final speed v and the initial height h.

What are some advantages of this model and what are its limitations?



Slide 31

Evaluating Models

Like any tool, models have both advantages and limitations. Some limitations are:

- Idealization- Models simplify complex phenomena, but this can lead to inaccuracies. Some situations are simply too complicated to model accurately.
- Assumptions-models rely on assumptions, which may affect accuracy
- Incompleteness- No one model can capture every detail of a system and therefore only work well for certain condition and situations

Slide 32

Update to Content Accepted by SRP

Test your knowledge

The equation for speed is: $speed = \frac{d}{t}$

What are advantages of this model?

What are limitations of this model?

Slide 33

Test your knowledge

The equation for speed is: $speed = \frac{d}{t}$

What are advantages of this model?

Simple way to accurately predict or calculate speed.

What are limitations of this model?

It's incomplete and only accurate when there is no change in speed or direction.

Slide 49

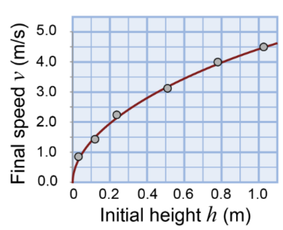
Assessment

4. A student made the mathematical model for the dropped marble:

$$v = 4.4\sqrt{h}$$

to describe the relationship between the final speed v and the initial height h.

What are some advantages of this model and what are its limitations?



Slide 50

Update to Content Accepted by SRP

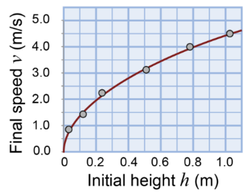
Assessment

4. A student made the mathematical model for the dropped marble:

$$v = 4.4\sqrt{h}$$

to describe the relationship between the final speed v and the initial height h.

What are some advantages of this model and what are its limitations?



The **advantages** of the model are it's **predictive powers** as it helps us forecast object motion easily. And the **conceptual clarity,** as it shows a clear height-speed relationship. One **limitation** is the **assumption** that all objects fall like marbles on Earth and it therefore may not work for light objects or on planets with different gravity. The model is also **idealized**, as it excludes air resistance, unlike real-world conditions.

(SE)(Breakout(s)) and (Citation Type(s))
(3)(C)(i), Activity

Description of the specific location and hyperlink to the exact location of currently adopted content
Page 7, left sidebar Lesson 2 Resources, Lesson Plan Waves, Electricity, light and the atom page 1 under Lesson plan segments, Student Work page 2 of Investigation 1B: Musical Sounds, and Answers page 2
https://education.pasco.com/epub/Physics/eBook-SBTE/BookInd-441.html

Description of the specific location and hyperlink to the exact location of the proposed new content
Page 7, left sidebar Lesson 2 Resources, Lesson Plan Waves Electricity, light and the atom page 1 under Lesson plan segments, Student Work page 2 of Investigation 1B: Musical Sounds, and Answers page 2
https://drive.google.com/drive/u/1/folders/1xG4hufKJpap9rWUlslmUt0zA2KpNcmMs

Screenshot of Currently Adopted Content

Insert a screenshot of your currently adopted content.

Lesson Plan

- Student work: *Waves, electricity, light and the atom* assignment
  Students should complete the assignment during the investigation. When everyone is finished, ask students to share their answers to Part 1, question c on the mathematical relationship between the frequency of a sound wave and the time it takes to make one complete oscillation.
- Investigation: Students explore the relationship between pitch, frequency, and period by selecting a set of frequencies, listening to the resulting sound, observing the waveform, and searching for patterns in the data.

Student Work Investigation 1B: Musical Sounds
n/a as this is new content added to the original document as Part 2: Scientific Argumentation, page 2 of Investigation B: Musical Sounds

Answers
n/a as this is new content added to the original document as Part 2: Scientific Argumentation, page 2 of Investigation B: Musical Sounds

Update to Content Accepted by SRP

Screenshot of Proposed New Content

Insert a screenshot of your proposed new content.

Lesson Plan

- Investigation: Students explore the relationship between pitch, frequency, and period by selecting a set of frequencies, listening to the resulting sound, observing the waveform, searching for patterns in the data and respectfully communicating their results in Claim-Evidence-Reasoning (CER) format.

- Student work: *Waves, electricity, light and the atom* assignment

Students should complete the assignment during the investigation. When everyone is finished, ask students to share their answers to Part 2 on the mathematical relationship between the frequency of a sound wave and the time it takes to make one complete oscillation. Students may come to different conclusions so gently guide them to develop a deeper understanding of the relationship between frequency and period. Encourage a respectful classroom discussion where students share their observations and use the formula to explain their findings.

Student Work

d. Share your Claim-Evidence-Reasoning (CER) paragraph with your partner or table group in a respectful manner. Did everyone's responses match? Record an additional claim, a new piece of evidence, or a different reasoning point from your classmates.

Answers

d. Share your Claim-Evidence-Reasoning (CER) paragraph with your partner or table group in a respectful manner. Did everyone's responses match? Record an additional claim, a new piece of evidence, or a different reasoning point from your classmates.

answer: Will vary based on the student's original claim and their group members.

Update to Content Accepted by SRP

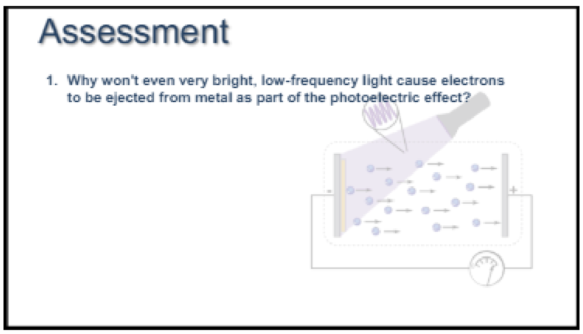
(SE)(Breakout(s)) and (Citation Type(s))
(3)(C)(i), Narrative

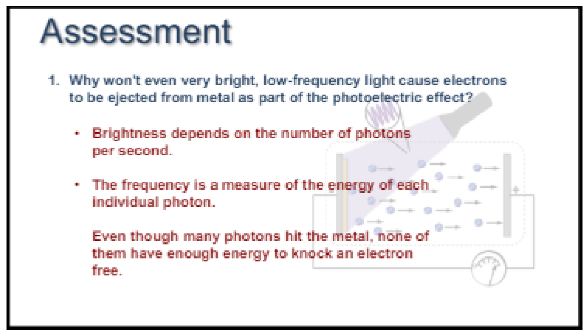
Description of the specific location and hyperlink to the exact location of currently adopted content.
Page 653, left sidebar Lesson 5 Resources, Slides 47-52
https://education.pasco.com/epub/Physics/eBook-SBTE/BookInd-1015.html

Description of the specific location and hyperlink to the exact location of the proposed new content
Will be located on page 653, left sidebar Lesson 5 Resources, Slides 47-52. This current resource supports 3C.i
https://drive.google.com/drive/u/1/folders/1xG4hufKJpap9rWUlslmUt0zA2KpNcmMs

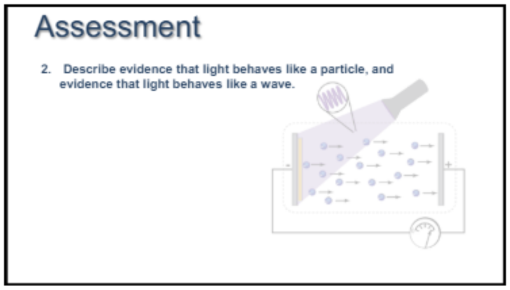
Screenshot of Currently Adopted Content

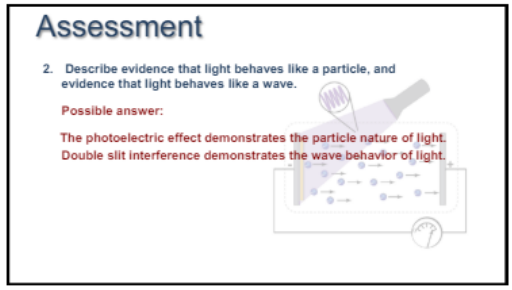
Insert a screenshot of your currently adopted content.
Slides 47-52

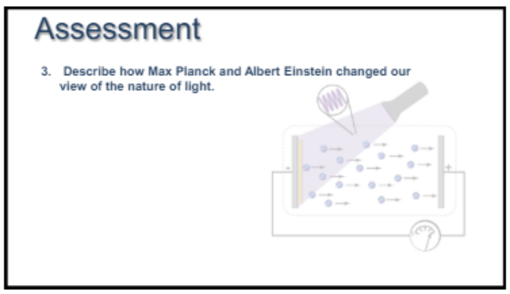


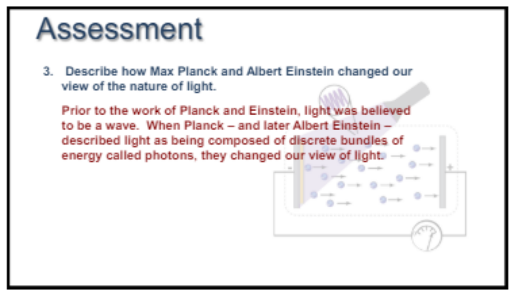


Update to Content Accepted by SRP









Screenshot of Proposed New Content

Insert a screenshot of your proposed new content.
Same as above

Update to Content Accepted by SRP

(SE)(Breakout(s)) and (Citation Type(s))
(9)(B)(i), Narrative and Activity

Description of the specific location and hyperlink to the exact location of currently adopted content
Page 648, left sidebar, Lesson 4 Resources, Lesson Plan Wave properties of light and Wave Properties of Light Slide presentation
https://education.pasco.com/epub/Physics/eBook-SBTE/BookInd-1181.html

Description of the specific location and hyperlink to the exact location of the proposed new content
Location in book will be the same. Link to view updated resources
https://drive.google.com/drive/u/1/folders/1xG4hufKJpap9rWUlslmUt0zA2KpNcmMs

Screenshot of Currently Adopted Content

Insert a screenshot of your currently adopted content.

Lesson Plan

Learning objectives

The student will be able to:
1) describe the dual nature of light;
2) describe ways in which light behaves like a wave; and
3) describe the role of wave characteristics and behaviors in industrial applications.

Lesson plan segments

- Demonstrations: Hold up one polarizing filter. Add another and rotate it until all of the light through the filters is blocked. Demonstrate the interference patterns that result when a hand-held laser shines through a diffraction grating. (Be sure to point the laser beam through the diffraction grating onto a wall – in a direction away from observers' eyes.)
- Slide presentation: The presentation describes diffraction patterns as examples of constructive and destructive interference of light waves that diffract around obstacles or through very thin slits, and illustrates the formation of maxima and minima patterns for double slit interference. The presentation relates diffraction to the technology of spectrographs that can be used to analyze incident light. Polarization is explained using a model of light as a transverse electromagnetic wave.

Assessment evidence

Objective 1: Light is said to have a dual nature. Which of these statements below best explains this phrase? (*in slide presentation*)

A. Light acts like both a mass and a spring.
B. Light exhibits both interference and diffraction.
C. Light behaves both like a wave and a particle.
D. Light conserves both energy and momentum.

Objective 2: Can these behaviors of light be explained using a wave model, a particle model, or both? (*in slide presentation*)

a. polarization — wave
b. photoelectric effect — particle
c. interference patterns — wave
d. reflection — both
e. diffraction — wave

Objective 3: What is a spectrograph and what technology might use a very large spectrograph? (*in slide presentation*)

answer: a spectrograph is a scientific instrument that uses diffraction to disperse light into its spectrum for analysis. Spectrographs can be very large when built for the largest telescopes on Earth.

Current Slides: n/a as proposed slides are new.

Screenshot of Proposed New Content

Insert a screenshot of your proposed new content.
Lesson Plan

Learning objectives

The student will be able to:
1) describe the dual nature of light;
2) describe ways in which light behaves like a wave, including polarization and Malus's law;
3) describe the role of wave characteristics and behaviors in industrial applications, such as, 3D movie glasses and LCD screens

Lesson plan segments

- Demonstrations: Hold up one polarizing filter. Add another and rotate it until all of the light through the filters is blocked. Demonstrate the interference patterns that result when a hand-held laser shines through a diffraction grating. (Be sure to point the laser beam through the diffraction grating onto a wall – in a direction away from observers' eyes.)

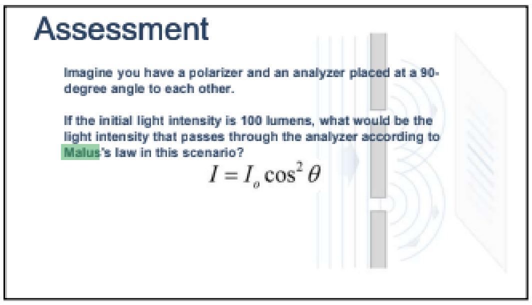
- Slide presentation: The presentation describes diffraction patterns as examples of constructive and destructive interference of light waves that diffract around obstacles or through very thin slits, and illustrates the formation of maxima and minima patterns for double slit interference. The presentation relates diffraction to the technology of spectrographs that can be used to analyze incident light. Polarization is explained using a model of light as a transverse electromagnetic wave. It touches on polarized light behavior, including Malus's law, 3D glasses and LCD screens.

Update to Content Accepted by SRP

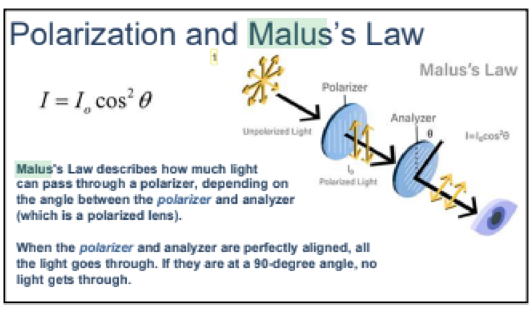
Objective 3: Imagine you have a polarizer and an analyzer placed at a 90-degree angle to each other. If the initial light intensity is 100 lumens, what would be the light intensity that passes through the analyzer according to Malus's law in this scenario? (*in slide presentation*)

answer: According to Malus's law, when the angle between the polarizer and analyzer is 90 degrees, the transmitted light intensity is reduced to zero so no light will pass through.

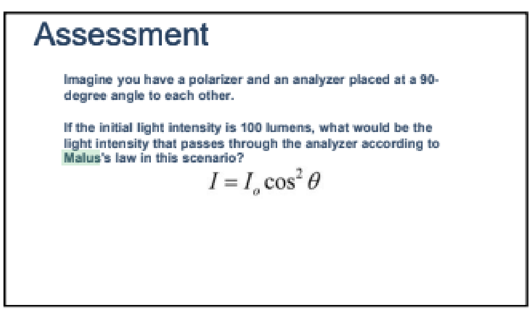
Proposed Slides 6, 43, 58, 59



6



43



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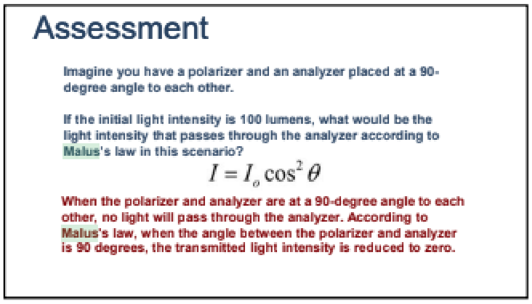

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(SE)(Breakout(s)) and (Citation Type(s))
(9)(B)(ii), narrative and activity

Description of the specific location and hyperlink to the exact location of currently adopted content
Page 648, left sidebar, Lesson 4 Resources Lesson Plan and Slide Presentation
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Learning objectives

The student will be able to:
1) describe the dual nature of light;
2) describe ways in which light behaves like a wave; and
3) describe the role of wave characteristics and behaviors in industrial applications.

Lesson plan segments

- Demonstrations: Hold up one polarizing filter. Add another and rotate it until all of the light through the filters is blocked. Demonstrate the interference patterns that result when a hand-held laser shines through a diffraction grating. (Be sure to point the laser beam through the diffraction grating onto a wall – in a direction away from observers' eyes.)

- Slide presentation: The presentation describes diffraction patterns as examples of constructive and destructive interference of light waves that diffract around obstacles or through very thin slits, and illustrates the formation of maxima and minima patterns for double slit interference. The presentation relates diffraction to the technology of spectrographs that can be used to analyze incident light. Polarization is explained using a model of light as a transverse electromagnetic wave.

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Lesson Plan

Learning objectives

The student will be able to:

1) describe the dual nature of light;
2) describe ways in which light behaves like a wave, including polarization and Malus's law;
3) describe the role of wave characteristics and behaviors in industrial applications, such as, 3D movie glasses and LCD screens

Lesson plan segments

- Demonstrations: Hold up one polarizing filter. Add another and rotate it until all of the light through the filters is blocked. Demonstrate the interference patterns that result when a hand-held laser shines through a diffraction grating. (Be sure to point the laser beam through the diffraction grating onto a wall – in a direction away from observers' eyes.)

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Proposed Slides 48, 61-62

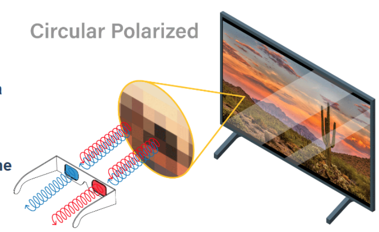
Polarizing filters: 3D Movie Glasses

Polarized light is typically linear, but circular *polarization* exists.

3D glasses utilize this to show each eye a different image with a specific *polarization*.

One lens passes clockwise-*polarized* light, and the other passes counterclockwise.

This creates the 3D effect when your brain combines the images.



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Assessment

6. Both 3D glasses and LCD screens use polarized lenses to create the images you see.

   How do they differ in how they manipulate light?

Assessment

6. Both 3D glasses and LCD screens use polarized lenses to create the images you see.

   How do they differ in how they manipulate light?

   3D glasses use polarized filters to show each eye a different image of light spinning either clockwise or counterclockwise, creating a 3D effect.

   LCD screens, in contrast, use liquid crystals to control light polarization, which manages the amount of light that passes through the polarizing screen to display colors and images.

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Lesson Plan

Learning objectives

The student will be able to:
1) describe the dual nature of light;
2) describe ways in which light behaves like a wave; and
3) describe the role of wave characteristics and behaviors in industrial applications.

Lesson plan segments

- Demonstrations: Hold up one polarizing filter. Add another and rotate it until all of the light through the filters is blocked. Demonstrate the interference patterns that result when a hand-held laser shines through a diffraction grating. (Be sure to point the laser beam through the diffraction grating onto a wall – in a direction away from observers' eyes.)

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Slide presentation: n/a as proposed content will fill the gaps.

Screenshot of Proposed New Content

Insert a screenshot of your proposed new content.

Lesson Plan

Learning objectives

The student will be able to:
1) describe the dual nature of light;
2) describe ways in which light behaves like a wave, including polarization and Malus's law;
3) describe the role of wave characteristics and behaviors in industrial applications, such as, 3D movie glasses and LCD screens

Update to Content Accepted by SRP

Lesson plan segments

- Demonstrations: Hold up one polarizing filter. Add another and rotate it until all of the light through the filters is blocked. Demonstrate the interference patterns that result when a hand-held laser shines through a diffraction grating. (Be sure to point the laser beam through the diffraction grating onto a wall – in a direction away from observers' eyes.)

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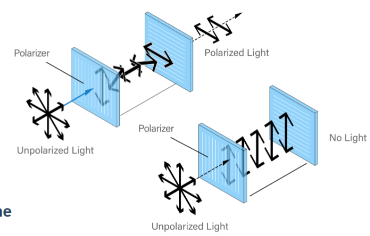
Proposed Slide 47, 61-62

Polarized Screens: LCD Screens

LCD screens use an array of pixels, each made of two *polarizer* layers with liquid crystals in between.

Applying an electric current causes the liquid crystals to twist the *polarization* of light.

This controls the light that passes through and creates the screen's colors and images.



Assessment

6. **Both 3D glasses and LCD screens use polarized lenses to create the images you see.**

   How do they differ in how they manipulate light?

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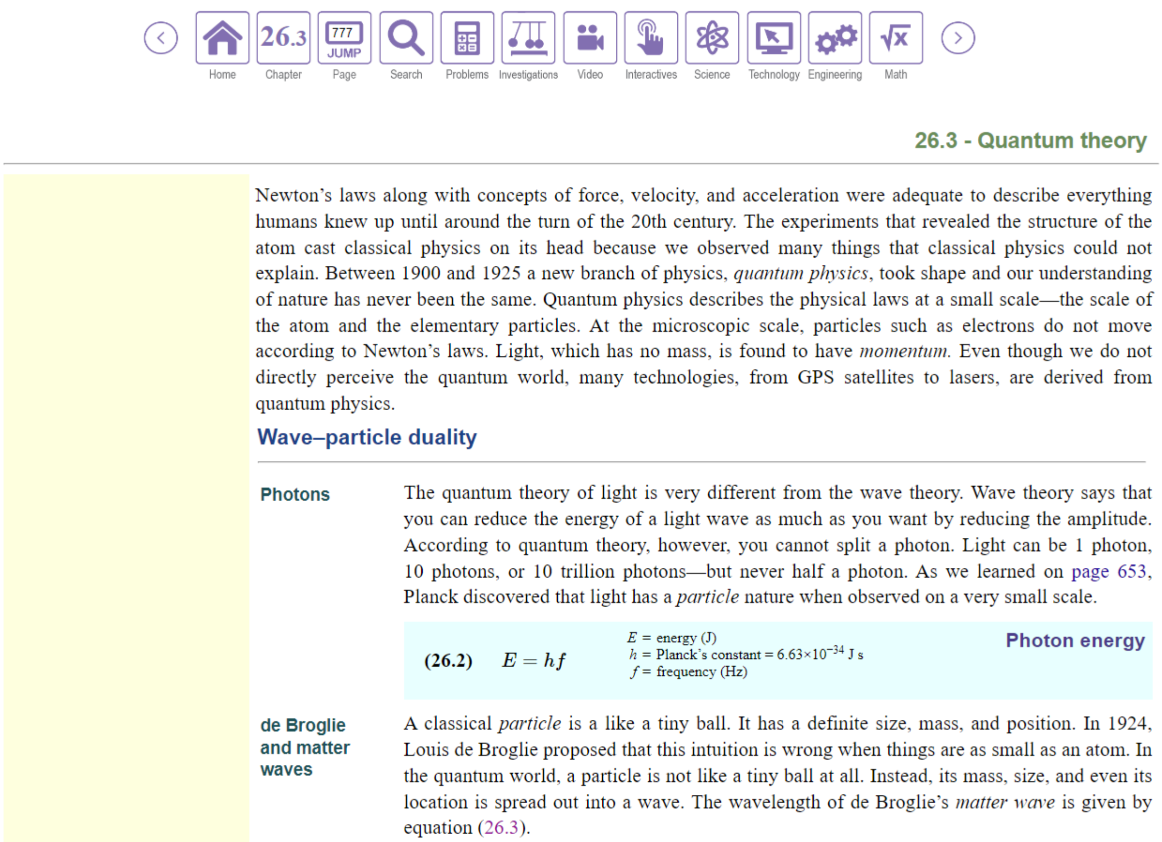

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26.3 - Quantum theory

Newton's laws along with concepts of force, velocity, and acceleration were adequate to describe everything humans knew up until around the turn of the 20th century. The experiments that revealed the structure of the atom cast classical physics on its head because we observed many things that classical physics could not explain. Between 1900 and 1925 a new branch of physics, *quantum physics*, took shape and our understanding of nature has never been the same. Quantum physics describes the physical laws at a small scale—the scale of the atom and the elementary particles. At the microscopic scale, particles such as electrons do not move according to Newton's laws. Light, which has no mass, is found to have *momentum*. Even though we do not directly perceive the quantum world, many technologies, from GPS satellites to lasers, are derived from quantum physics.

Wave–particle duality

Photons The quantum theory of light is very different from the wave theory. Wave theory says that you can reduce the energy of a light wave as much as you want by reducing the amplitude. According to quantum theory, however, you cannot split a photon. Light can be 1 photon, 10 photons, or 10 trillion photons—but never half a photon. As we learned on page 653, Planck discovered that light has a *particle* nature when observed on a very small scale.

Photon energy

(26.2) $E = hf$

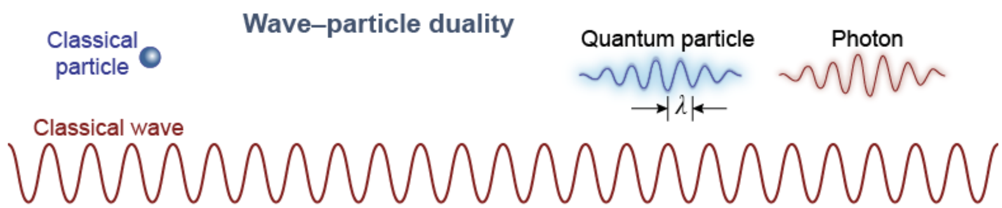
E = energy (J)
h = Planck's constant = 6.63×10^{-34} J s
f = frequency (Hz)

de Broglie and matter waves A classical *particle* is a like a tiny ball. It has a definite size, mass, and position. In 1924, Louis de Broglie proposed that this intuition is wrong when things are as small as an atom. In the quantum world, a particle is not like a tiny ball at all. Instead, its mass, size, and even its location is spread out into a wave. The wavelength of de Broglie's *matter wave* is given by equation (26.3).

de Broglie wavelength

$$(26.3) \quad \lambda = \frac{h}{p}$$

λ = wavelength (m)
h = Planck's constant = 6.63×10^{-34} J s
p = momentum (kg m/s)



What is duality?

The fact that light has particle aspects and matter has wave aspects on the quantum level is called *wave–particle duality,* which we learned about on page 657. The particle nature of light becomes evident when the energy of a system gets close to the photon energy. The wave nature of matter becomes evident when the size of a system becomes comparable to the de Broglie wavelength. Both equations involve Planck's constant h, which is a characteristic of the quantum world.

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Double slit experiment for electrons

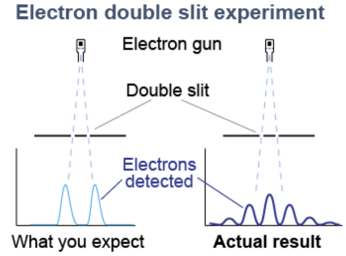
Questions to think about

The behavior of electrons in atoms is complex and *strange!* Why should there be energy levels? Why should the first level hold two electrons, the second hold eight electrons, and so on? What creates the structure reflected in the periodic table and consequentially makes the infinite variety of matter possible, including life? Presenting the mathematics of quantum theory is more than we can do in this book, but we want to provide a conceptual framework for this incredibly successful theory.

Double slit experiment

Consider a barrier with two small slits. Electrons are emitted and some pass through the slits and fall on a screen where they are detected. If electrons were classical particles they would be detected in two places, directly in line with each slit. In fact, when the experiment is done with very small slits, something very different happens. We do *not* see two maxima in front of the slits. Instead, we see an *interference pattern* that is characteristic of two waves.

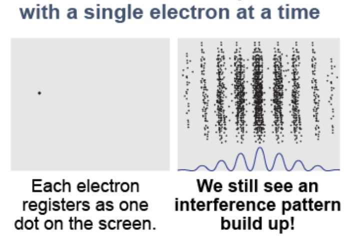
Electron double slit experiment



Single electrons and the double slit

The experiment gets even more interesting if we let only *one* electron at a time pass through the slits. A single electron is detected at one place on the screen each time the electron gun fires. The weird thing occurs when we record where each electron strikes the screen for 10,000 electrons *one at a time.* We accumulate the *same interference pattern* one electron at a time as we did when there were many electrons at once!

Electron double slit experiment with a single electron at a time



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The electron must be a wave

The one-at-a-time result implies that a single electron somehow passes through *both slits at the same time to interfere with itself!* Our classical concept of an electron as a particle with a definite position is *not* adequate to explain the double slit experiment. If the electron is a wave, however, then we can explain the two-slit diffraction pattern by constructive and destructive interference.

Why we don't usually see the electron wave

Early experimentalists did not see the electron wave because the slits have to be on the order of the electron wavelength in size. Electrons are so light that a 1.5 V battery will accelerate them to a velocity of 726,000 m/s! At this velocity, the electron wavelength is 1 nanometer (10^{-9} m). Quantum effects generally become evident when a system is of the order of the electron wavelength.

Energy of charge q moving across voltage V

$$qV = \tfrac{1}{2}mv^2 \rightarrow v = \sqrt{\frac{2eV}{m_e}}$$

$$v = \sqrt{\frac{2(1.6\times10^{-19}\ \text{C})(1.5\ \text{V})}{9.11\times10^{-31}\ \text{kg}}}$$

$$= 726{,}000\ \text{m/s}$$

Screenshot of Proposed New Content

Insert a screenshot of your proposed new content.

Lesson Plan

Quantum Theory

Content Learning objectives

In this lesson, students

The student will be able to:

1. understand how superposition of quantum states is related to the wave-particle duality nature of light and matter.
2. identify and give examples of applications of quantum phenomena.

Materials/ technology resources

1. Slide presentation:"QuantumTheory.pptx"

Lesson plan segments

- <u>Whole group discussion</u>: Ask students, have you ever seen or used something in your daily life that might involve quantum physics without realizing it?
- <u>Slide presentation</u>: The presentation introduces students to the engineering design process, and the basic physics behind an infrared pulse monitor. It then leads students through designing their own infrared pulse monitor.

- Reading: from the *Essential Physics* textbook, page 777

Prior knowledge	Students should be familiar with circuit construction and basic circuit elements. Students should understand the electromagnetic spectrum, and where infrared light is located within that spectrum.
Equations	*E=hf* *pxh4* *Eth4*
Vocabulary	quantum theory wave-particle duality double slit experiment superposition uncertainty principle
Standards	The student is expected to: • Compare and explain how superposition of quantum states is related to the wave-particle duality nature of light. • Give examples of applications of quantum phenomena, including the Heisenberg uncertainty principle, quantum computing, and cybersecurity.
Crosscutting concepts	Patterns; Cause and Effect; Systems and Models; Energy and Matter; Structure and Function; Stability and Change; Scale, Proportion, Quantity • Quantum physics explains the behavior of the world at very small scales.

Key to differentiated instruction:	visual	linguistic	auditory
interpersonal	intrapersonal	kinesthetic	logical

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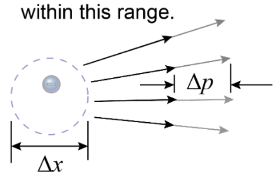
Proposed Slide Presentation Slides 9-10, and 16

Heisenberg's Uncertainty Principle

- **Can we know an electron's position and momentum at the same time?**
- **According the Heisenberg's Uncertainty Principle, observing quantum systems disrupts them, making precise measurements of both impossible.**
- **The uncertainty principle restricts simultaneous measurement accuracy.**

$$\Delta p \Delta x \geq \frac{h}{4\pi}$$

Uncertainty in momentum
The electron can have any momentum within this range.



Uncertainty in position
The electron can be anywhere inside this circle.

Energy and Time Uncertainty

$$\Delta E \Delta t \geq \frac{h}{4\pi}$$

- **The quantum world's fundamental unpredictability for single particles.**
- **Uncertainty principle applies to macroscopic scale, causing energy and time measurement uncertainties.**
- **Energy-time uncertainty allows brief violations of energy conservation if events quickly reverse, like a particle briefly appearing and disappearing within $h/4\pi$ limits.**

Assessment

1. **Heisenberg's Uncertainty Principle states** $\Delta p \Delta x \geq \frac{h}{4\pi}$

   Imagine you have an electron contained within a space, of width Δx. Now you decrease the width of the space. What happens to the uncertainty in momentum Δp?

When the width of the space decreases, the uncertainty in momentum must increase.

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See (9)(D)(i), Chapter 26 Quantum Theory

Screenshot of Proposed New Content

Insert a screenshot of your proposed new content. Quantum Theory Lesson Plan page 2

<table>
<tr><td>Prior knowledge</td><td colspan="7">Students should be familiar with circuit construction and basic circuit elements. Students should understand the electromagnetic spectrum, and where infrared light is located within that spectrum.</td></tr>
<tr><td>Equations</td><td colspan="7">E=hf pxh4 Eth4</td></tr>
<tr><td>Vocabulary</td><td colspan="7">quantum theory wave-particle duality
double slit experimentsuperposition
uncertainty principle</td></tr>
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<tr><td colspan="7">• Quantum physics explains the behavior of the world at very small scales.</td></tr>
</table>

<table>
<tr><td>Key to differentiated instruction:</td><td>visual</td><td>linguistic</td><td>auditory</td></tr>
<tr><td>interpersonal</td><td>intrapersonal</td><td>kinesthetic</td><td>logical</td></tr>
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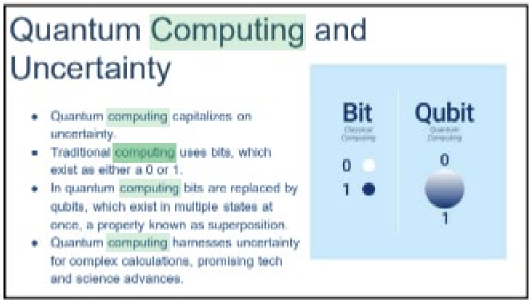
Proposed Slides 10-12



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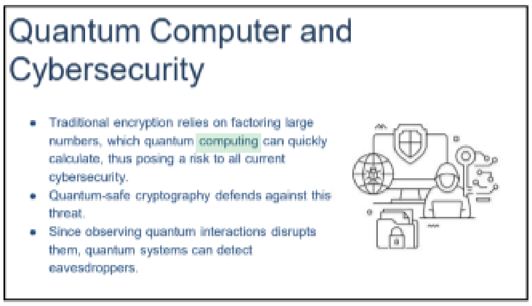

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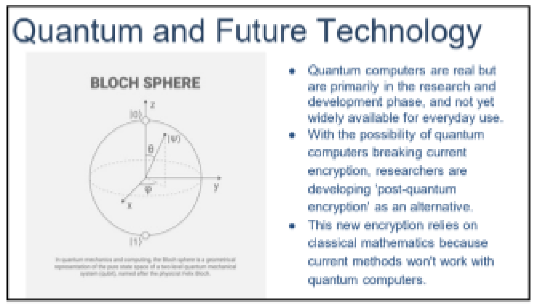

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See (9)(D)(i), Chapter 26 Quantum Theory screenshots of text within textbook

Screenshot of Proposed New Content

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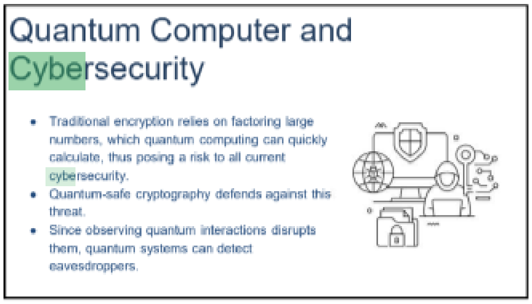

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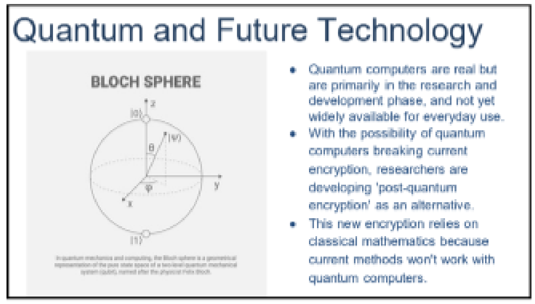

12

Assurances

These assurances apply to all material submitted to update content in state-adopted instructional materials.

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Publisher acknowledges that:

- There will be no additional cost to the state;
- The new material meets the applicable Texas Essential Knowledge and Skills (TEKS), English Language Proficiency Standards (ELPS), or Texas Prekindergarten Guidelines (TPG) and is free from factual errors; and
- The updates in the new edition do not affect the product's coverage of Texas Education Code (TEC), §28.002(h), as it relates to that specific subject and grade level or course(s), understanding the importance of patriotism and functioning productively in a free-enterprise society with appreciation for the basic democratic values of our state and national heritage.

Signature: By entering your name below, you are confirming the above assurances, and signing this document electronically. You agree that your electronic signature is the equivalent of your manual signature.

Heidi Brennan

Date Submitted: 6/19/2024