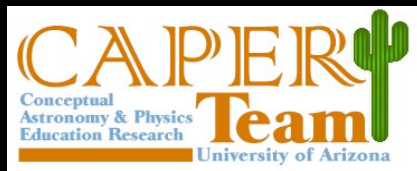


Visual Activities for Assessing Non-science Majors' Understanding in Intro Astronomy



Daniel Loran
Truckee Meadows Community College
dloranz@scs.unr.edu



Edward E. Prather
& Timothy F. Slater
University of Arizona

What is a Visual Activity?

A conceptual exercise that couples ..._

Conceptually
rich questions.



Interactive tools -

- Simulations
- Figures
- Photos

The union enhances formative
& summative assessment._

See for example ...

Cox, A.J., Belloni, M., Dancy, M., & Christian, W. 2003. "Teaching thermodynamics with Physlets in introductory physics," *Physics Education*, **38**(5)

What is a Visual Activity?

A conceptual exercise that couples ..._

Conceptually
rich questions.



Interactive tools -

- Simulations
- Figures
- Photos

Paired with feedback & hints served
from a database, VA's present
interesting opportunities for self-
paced activities - e.g. homework.

Multiple Platforms are Available

This talk's examples are on Mastering-Astronomy

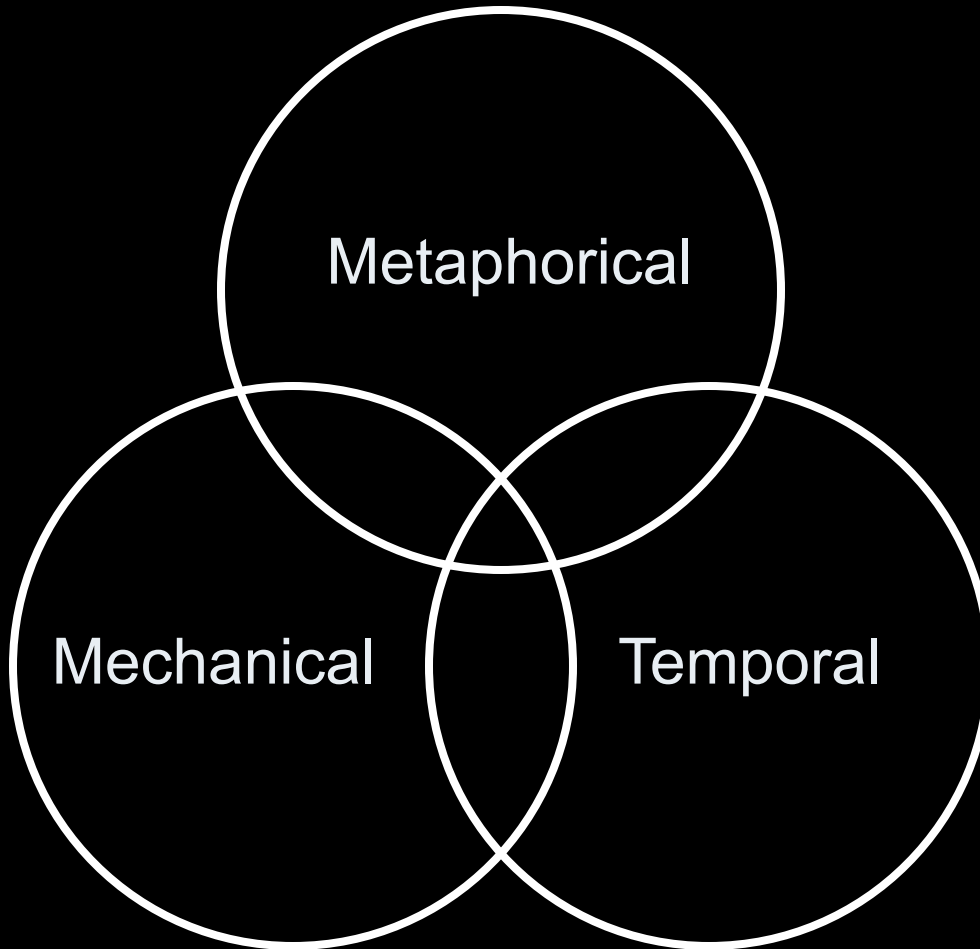
Question Branches

- MOODLE
- LON-CAPA

Interactive Figures

- Flash
- JAVA & JavaScript

Overlapping Genres of Interactive Tools

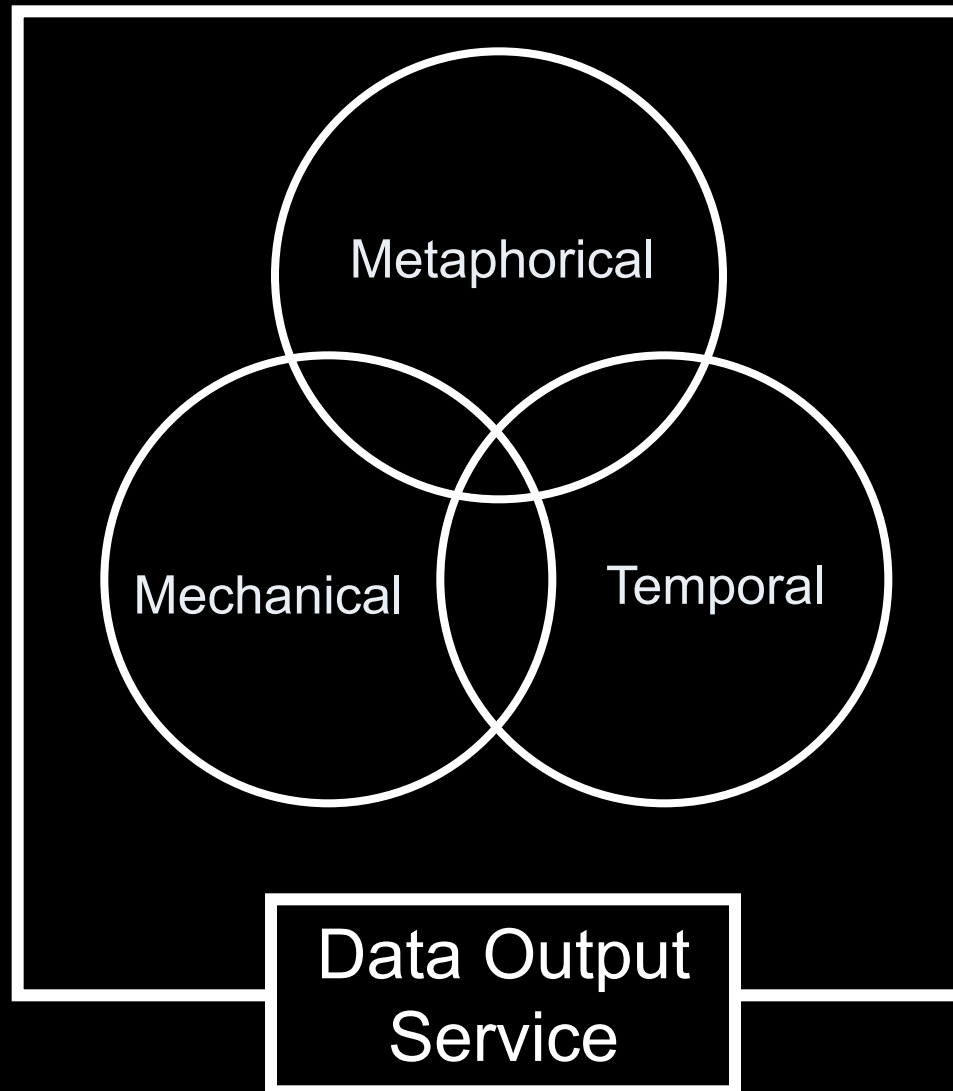


Metaphorical -
tells a story.

Mechanical -
exposes a
mechanism.

Temporal -
displays evolution
in time.

Overlapping Genres of Interactive Tools



Data Output
can be ...

- Automated
- Student gathered

Example data ...

- mass
- position
- elapsed time

Examples: Mechanical

STP Visual Activity Exploring the Path of the Sun Over a Year

Difficulty: 1 Time: 6m

Action: (select action)

Visual Activity Exploring the Path of the Sun Over a Year

Daniel Loran

Intro 1

Exploring the Path of the Sun Over a Year

Sun right ascension 036 deg

[Hide Sun path](#)

[Hide sight line](#)

[Show graticule](#)

Sun declination

0.0

+ 23.5

0

- 23.5

Date Sep 21

or Mar 21

Observers latitude 40 deg

90° 66.5° 23.5° 0° 23.5° 66.5° 90°

North South

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How To Use Credits

Part A

Explore the interactive figure thoroughly before answering the questions. Be sure to note that strictly for exploration purposes, the figure allows you to separately adjust both the Sun's right ascension (RA) and declination (dec), when in fact these are not independent of each other.

Due to Earth's rotation, the Sun appears to trace out a complete circle centered on Earth every 24 hours. Imagine viewing the sky from somewhere north of 66.5 degrees north latitude (the Arctic Circle) during the summer solstice (June 21). How much of the Sun's apparent path through the sky would you observe during one 24-hour period?

☐ less than half the circular path of the Sun

☐ exactly half the circular path of the Sun

☐ more than half (but not all) the circular path of the Sun

☐ the whole circular path of the Sun

[submit](#)
[hints](#)
[my answers](#)
[give up](#)
[review part](#)

Part B

If viewing the sky from anywhere on the equator, how much of the Sun's apparent path through the sky would you observe during one 24-hour period?

☐ During the summer months you would observe more than half the circular path of the Sun.

☐ During the winter months you would observe less than half the circular path of the Sun.

☐ You would observe exactly half the circular path of the Sun – but only on each equinox.

☐ You would observe exactly half the circular path of the Sun any day of the year.

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[hints](#)
[my answers](#)
[give up](#)
[review part](#)

Part C

Consider the following statements about the Sun's maximum altitude as seen at different locations on different days of the year.

1. If located somewhere in the northern hemisphere, you will see the Sun reach a higher altitude in your sky on June 21 than on December 21.
2. Regardless of your location on Earth, the Sun passes directly overhead every day at local noon.
3. If located anywhere on the equator, the Sun will pass directly over your head every day at local noon.
4. If located anywhere on the equator, you will see the Sun reach a higher point in the sky on June 21 than on March 21.

Which are true?

Examples: *Mechanical*

STP

Visual Activity: Phases of Venus

Difficulty: 1

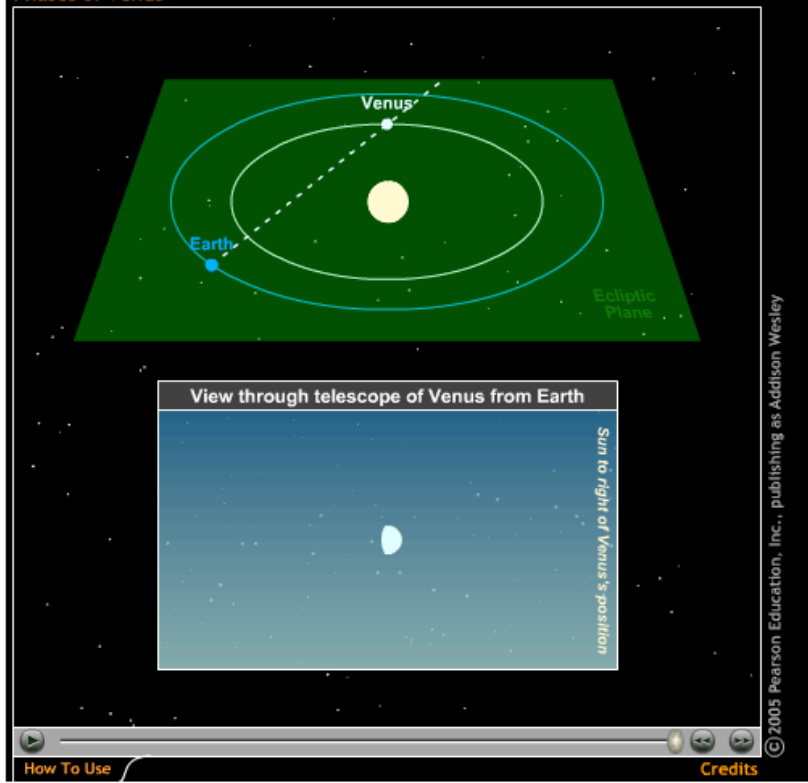
Time: 9m

Action: (select action)

Visual Activity: Phases of Venus

Intro 1

Phases of Venus



How To Use

Credits

Part B

In the Earth-centered model of the solar system, Venus never appears opposite the Sun in our sky, and the distance between Venus and Earth does not change very much. Given that the Sun (and not Earth) is really at the center of our solar system, which of the following statements is true?

- ☐ Venus never appears opposite the Sun in our sky, and the distance between Venus and Earth does not change very much.
- ☐ Venus never appears opposite the Sun in our sky, but the distance between Venus and Earth changes dramatically.
- ☐ Venus and the Sun sometimes appear opposite each other in our sky, but the distance between Venus and Earth does not change very much.
- ☐ Venus and the Sun sometimes appear opposite each other in our sky, and the distance between Venus and Earth changes dramatically.

[submit](#) [hints](#) [my answers](#) [give up](#) [review part](#)

Part C

When would a new Venus be high in the sky?

- ☐ noon
- ☐ sunset
- ☐ midnight
- ☐ sunrise

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Part D

Which phase of Venus would you expect to see high in the sky at midnight?

- ☐ waxing gibbous
- ☐ waning crescent
- ☐ full
- ☐ No phase is visible since Venus is *never* high in the sky at midnight.

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Part E

Knowing that Venus always appears relatively near the Sun in our sky, which phases of Venus can only occur because Venus and Earth both orbit the Sun?

- ☐ new Venus phase
- ☐ crescent Venus phases
- ☐ gibbous (nearly but not quite full) Venus phases

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Examples: *Temporal*

STP

Visual Activity: The Life Track of a One-Solar-Mass Protostar

Difficulty: 1

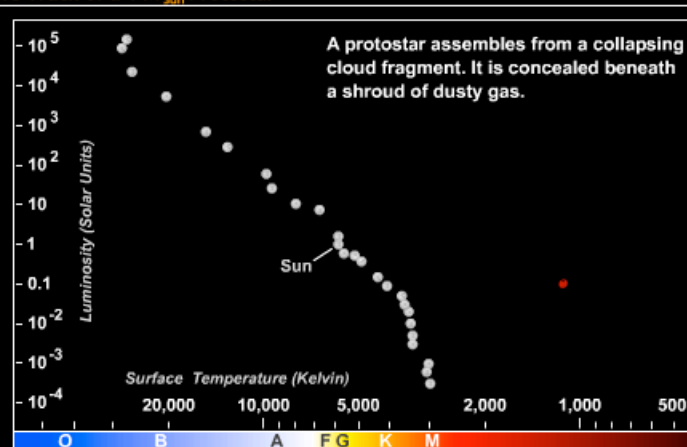
Time: 5m

Action: (select action)

Visual Activity: The Life Track of a One-Solar-Mass Protostar

Intro 1

Life Track of a $1 M_{\text{Sun}}$ Protostar



Luminosity (L_{Sun})

0.1

Temperature (K)

1100

How To Use

Credits

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Explore the interactive figure before beginning to answer the questions.

Part A

As a clump of interstellar gas contracts to become a main-sequence star, its changing position on the H-R diagram tells us _____.

- ☐ how it moves through the galaxy
- ☐ the time during which it existed in the history of the universe
- ☐ how its outward appearance is changing

[submit](#) [hints](#) [my answers](#) [give up](#) [review part](#)

Part B

How does the protostar change during the period of time just after losing its surrounding gas cloud (as it begins the final stages of becoming a main-sequence star)?

- ☐ Its surface temperature and luminosity both increase.
- ☐ Its surface temperature increases, but its luminosity decreases.
- ☐ Its surface temperature and luminosity both decrease.
- ☐ Its surface temperature decreases, but its luminosity increases.

[submit](#) [hints](#) [my answers](#) [give up](#) [review part](#)

Part C

When does a newly forming star have the greatest luminosity?

- ☐ when its surface temperature is the highest
- ☐ right when it first becomes a main-sequence star
- ☐ sometime during its protostar stage
- ☐ when its internal temperature is highest

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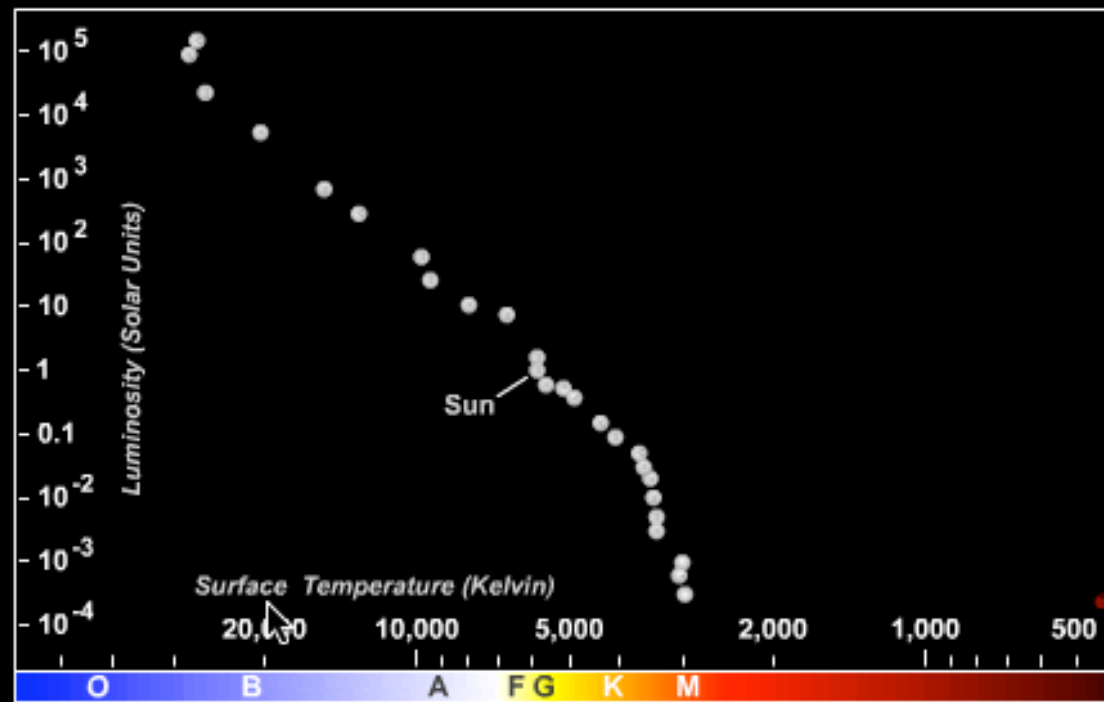
Part D

When a newly forming star is at its greatest luminosity, what is its energy source?

- ☐ gravitational contraction
- ☐ nuclear fusion of hydrogen into helium
- ☐ radioactive decay of unstable isotopes
- ☐ A newly forming star has no energy source, since it does not shine at all until it becomes a true main-sequence star.

[submit](#) [hints](#) [my answers](#) [give up](#) [review part](#)

Life Track of a 1 M_{Sun} Protostar



Luminosity (L_{Sun})

0.0004

Temperature (K)

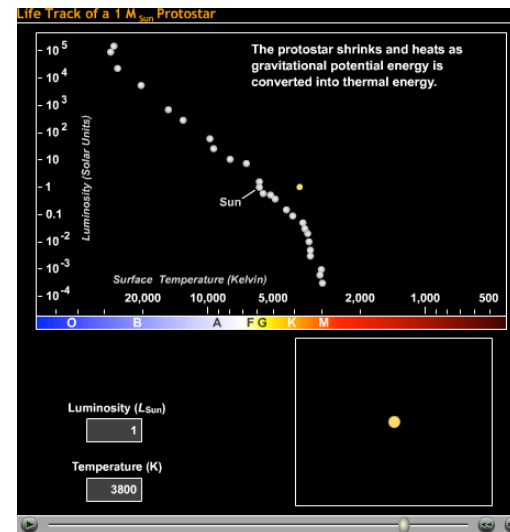
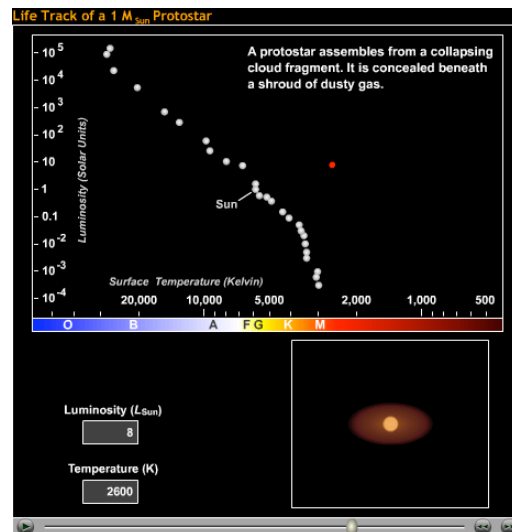
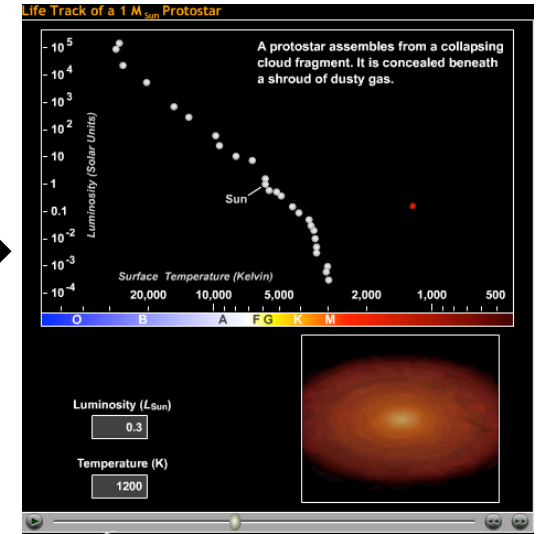
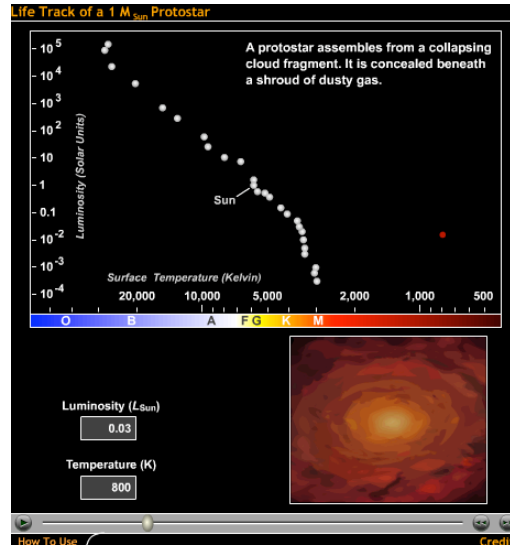
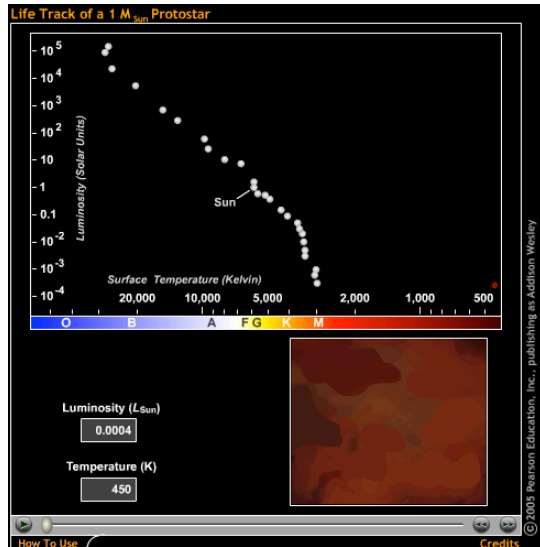
450



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How To Use

Credits



Examples: *Metaphorical*

STP

Visual Activity: Exploring the Cause of the Greenhouse Effect

Difficulty: 1

Time: 4m

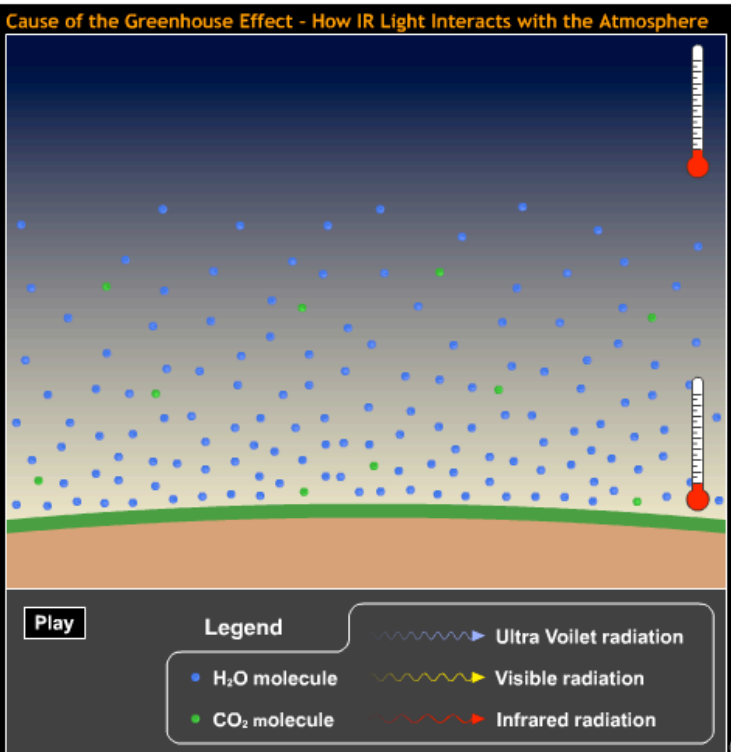
Action: (select action) ▾

Visual Activity: Exploring the Cause of the Greenhouse Effect

Daniel Loran

Intro 1

Cause of the Greenhouse Effect - How IR Light Interacts with the Atmosphere



Play

Legend

H₂O molecule

CO₂ molecule

Ultra Violet radiation

Visible radiation

Infrared radiation

How To Use

Credits

Explore the interactive figure before answering the questions. Note that, in the interactive figure, while Earth's surface is changing temperature the surface thermometer flashes. You will be able to change the atmospheric composition and the cloud cover only after the thermometer has stopped flashing.

Part A

On a cloudless day, what happens to most of the visible light headed toward Earth?

☐ It is reflected by Earth's atmosphere.

☐ It is absorbed and reemitted by gases in Earth's atmosphere.

☐ It is completely reflected by Earth's surface.

☐ It reaches Earth's surface and is either scattered or absorbed and its energy gets reradiated as infrared light.

submit

hints

my answers

give up

review part

Part B

On a day with complete cloud cover, what happens to much of the visible light headed toward Earth?

☐ It is scattered by the clouds in Earth's atmosphere.

☐ It is absorbed by the clouds in Earth's atmosphere and reemitted as infrared radiation.

☐ It passes directly through the clouds in Earth's atmosphere.

submit

hints

my answers

give up

review part

Part C

The greenhouse effect causes Earth's surface temperature to be higher because the infrared light radiated by Earth's surface _____.

☐ travels directly out to space

☐ becomes permanently trapped by greenhouse gases

☐ is temporarily absorbed by greenhouse gases and then reemitted as infrared light

☐ is temporarily absorbed by greenhouse gases and then reemitted as UV light

submit

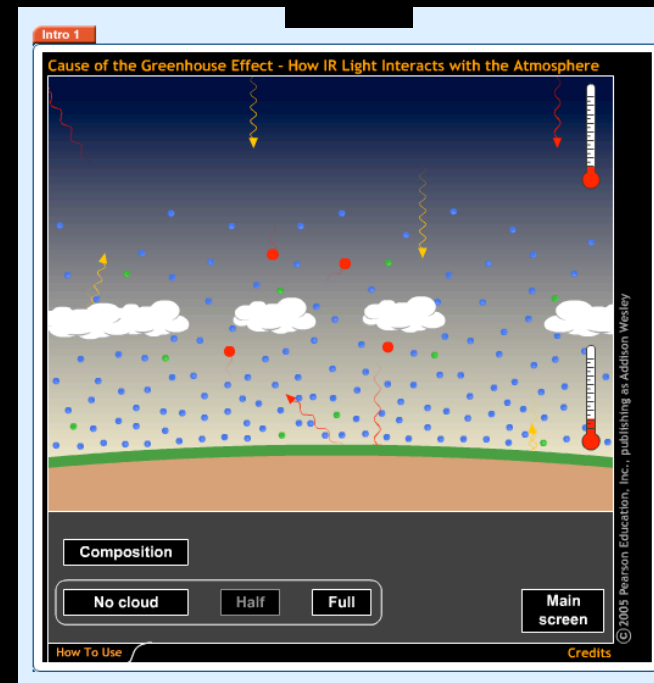
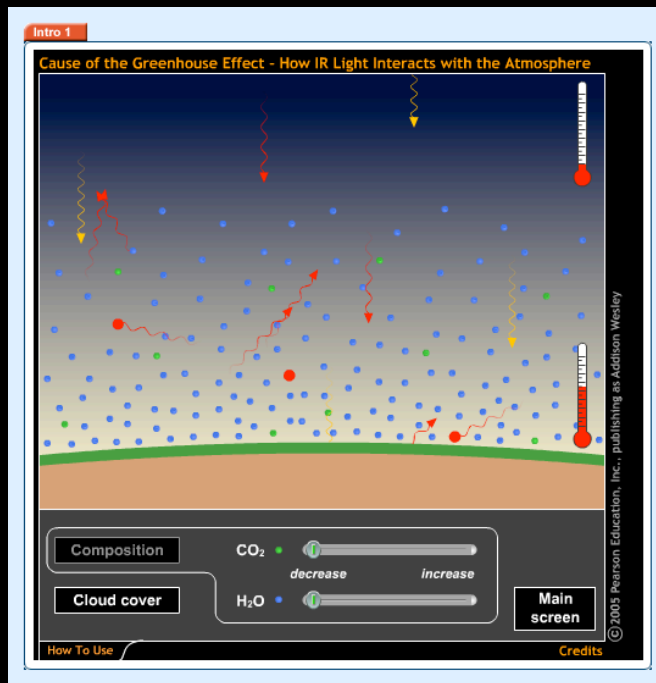
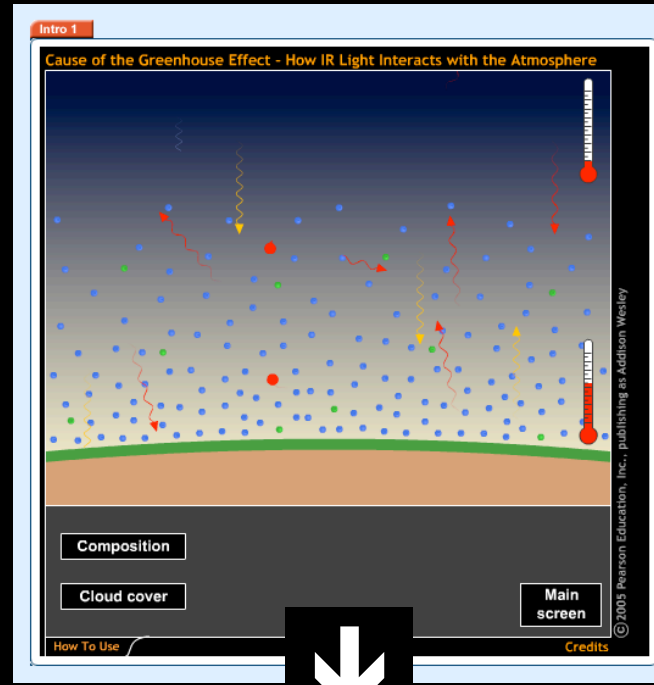
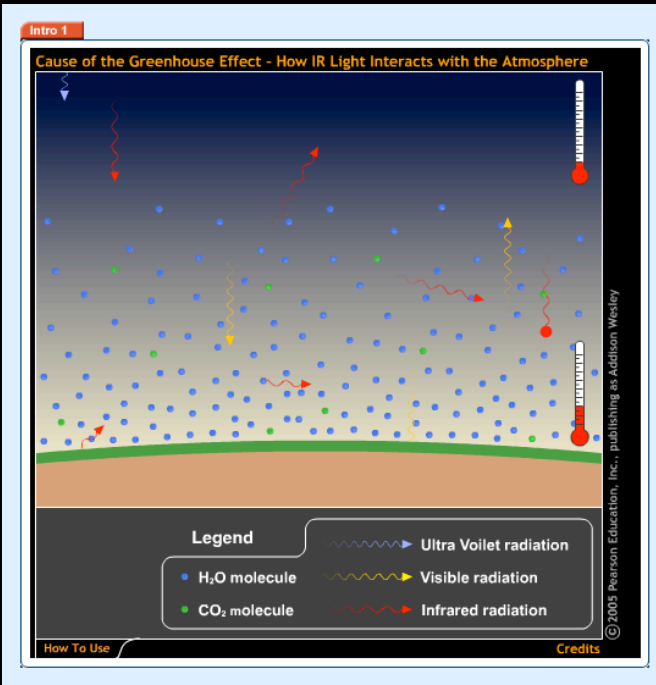
hints

my answers

give up

review part

submit problem



Current Status

1. 28 VA's sampling full range of Intro-Astro 2. Initial student response data

Item 1

The Solar Thermostat

Click away of Sun

Inside the core

Equilibrium is regained

Increased core temp

Reset

Temperature of the core

Rate of fusion

Height

How to Use

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Part A

Explore the interactive figure before beginning to answer the questions.

Which of the following changes would cause the fusion rate in the Sun's core to increase?

A. Increase the temperature in the core.
B. Expand the radius of the core.
C. Decrease the temperature in the core.
D. Compress the radius of the core.

Enter the letters of all correct statements in alphabetical order (without spaces). For example, if statements C and D are correct, enter CD.

Submit Answer Flag question Give up Reveal part

Part B

What would happen if the fusion rate in the core of the Sun were increased but the core could not change size?

☐ The Sun's core would start to cool down and the rate of fusion would decrease.
☐ The Sun's core would reach a new equilibrium at a lower temperature.
☐ The Sun's core would reach a new equilibrium at a higher temperature.
☐ The Sun's core would start to heat up and the rate of fusion would increase even more.

Submit Answer Flag question Give up Reveal part

Part C

Which of the following must occur for a star's core to reach equilibrium after an initial change in fusion rate?

A. If the fusion rate initially decreases, then the core expands.
B. If the fusion rate initially increases, then the core expands.
C. If the fusion rate initially increases, then the core contracts.
D. If the fusion rate initially increases, then the core contracts.

Enter the letters of all correct statements in alphabetical order (without spaces). For example, if statements C and D are correct, enter CD.

Submit Answer Flag question Give up Reveal part

Item 2

Atmospheric Absorption of Light at Different Wavelengths

Image of Sun

Height

How to Use

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Part A

Explore the figure thoroughly before beginning to answer the questions. You can raise the observatory first shown as a dome icon at sea level to different altitudes to explore different wavelengths of light. Also, note that the figure is only a schematic representation that shows where most of a particular form of light is absorbed.

A telescope located on Earth's surface would be best suited for observing most _____ wavelengths.

☐ X-ray and visible
☐ ultraviolet and radio
☐ visible and radio
☐ infrared and visible
☐ infrared and X-ray

Submit Answer Flag question Give up Reveal part

Part B

Fast eyes were sensitive only to X-rays, the world would appear _____.

☐ gray, black, and white like a medical X-ray
☐ brighter than normal because X-ray light is very energetic
☐ dark since X-ray light does not reach Earth's surface
☐ the same as now because visible light would still reach Earth's surface

Submit Answer Flag question Give up Reveal part

Part C

If you had only one telescope and wanted to take both visible light and ultraviolet pictures of stars, where should you locate your telescope?

☐ at sea level
☐ on a tall mountain
☐ in an airplane
☐ in space

Submit Answer Flag question Give up Reveal part

Item 3

The Spectrum of Spectra - Illustrating Kirchhoff's Laws

Show

Continuous Spectrum

The spectrum shows a smooth, continuous rainbow of light.

A graph of the spectrum in this figure shows intensity versus wavelength. The light bulb produces light with a continuous spectrum.

Show

Emission Line Spectrum

We see bright emission lines at specific wavelengths (color), but no other light.

The graph shows an upward spike at the wavelength of each emission line.

Show

Absorption Line Spectrum

We see dark absorption lines where the cloud has absorbed light of specific wavelengths (color).

The graph shows a dip in intensity at the wavelength of each absorption line.

How to Use

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Part A

Explore the interactive figure thoroughly before beginning to answer the questions.

What feature of the intensity graph for continuous spectra illustrates Wien's law—namely, that a higher temperature object emits photons with higher average energy?

☐ a higher value of intensity
☐ a shorter photon wavelength
☐ a longer photon wavelength

Submit Answer Flag question Give up Reveal part

Part B

Study the emission line spectrum for neon. (Click the "Show" button for the Emission Line Spectrum, and then click the "Choose gases" button and select neon.) The neon "OPEN" sign appears reddish-orange because

☐ neon atoms emit only yellow and red photons
☐ neon atoms emit many more yellow and red photons than blue and violet photons
☐ the yellow and red photons emitted by neon travel much faster than the blue and violet photons and so reach our eyes first
☐ each yellow and red photon emitted by neon carries more energy than each blue and violet photon emitted.

Submit Answer Flag question Give up Reveal part

Part C

Look at the absorption line spectrum shown in this figure. Consider viewing the gas cloud that creates this absorption line spectrum from a perspective that does not put the light bulb directly along your line of sight. In this case the spectrum would _____.

☐ appear completely dark
☐ still look like an absorption spectrum
☐ now look like an emission spectrum
☐ appear as a continuous rainbow of colors

Submit Answer Flag question Give up Reveal part

Item 4

From Stars to Black Holes - Altering the Curvature of Space-Time

Click and drag to move (dragging up or down)

Mass & radius controls

Object radius: small, medium, large

Black hole, White dwarf, Sun, Red giant

with mass equal to the Sun

Show Orbits

How to Use

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Part A

In the "Show Orbits" view of the figure, an observer at rest with respect to the Sun would say that the object in the elliptical orbit has the most acceleration where.

☐ apogee has the most curvature.
☐ apogee has the least curvature.
☐ apogee is changing from being more curved to less curved.
☐ apogee is changing from being less curved to more curved.

Submit Answer Flag question Give up Reveal part

Part B

In the "Show Orbits" view of the figure, how would the motion of a photon passing near the Sun compare to the motion shown in the "Unbowed orbit"?

☐ Like the object shown, the photon's path would also curve toward the Sun.
☐ Unlike the object shown, the photon's path would curve away from the Sun.
☐ Unlike the object shown, the photon's path would not curve toward or away from the Sun.
☐ Unlike the object shown, the photon would reach its closest distance to the Sun and then reverse direction, moving away along its original path.

Submit Answer Flag question Give up Reveal part

Part C

Imagine that the Sun could be turned into a black hole without changing its mass. How would the spacetime curvature at the location of the closest planet, Mercury, change? The curvature would be:

☐ much greater.
☐ a little greater.
☐ unchanged.
☐ a little less.
☐ much less.

Submit Answer Flag question Give up Reveal part

Item 5

Gravitational Time Dilation and Redshifts

How to Use

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Part A

Explore the animation before beginning to answer the questions.

At the falling rocket plunges toward the event horizon, how will the clock readings aboard and the light ship gives off appear to change, when viewed by the observer in the orbiting rocket? The orbiting observer would see that the falling rocket has a clock that runs _____.

☐ increasingly faster and emits light that is increasingly blueshifted
☐ increasingly faster and emits light that is increasingly redshifted
☐ increasingly slower and emits light that is increasingly blueshifted
☐ increasingly slower and emits light that is increasingly redshifted

Submit Answer Flag question Give up Reveal part

Part B

At the falling rocket plunges toward the event horizon, an observer in the orbiting rocket would see that the falling rocket _____.

☐ slows down and appears to stop at the event horizon
☐ slows down but still eventually crosses the event horizon
☐ moves at constant speed and eventually crosses the event horizon
☐ speeds up, while falling and crosses the event horizon at high speed

Submit Answer Flag question Give up Reveal part

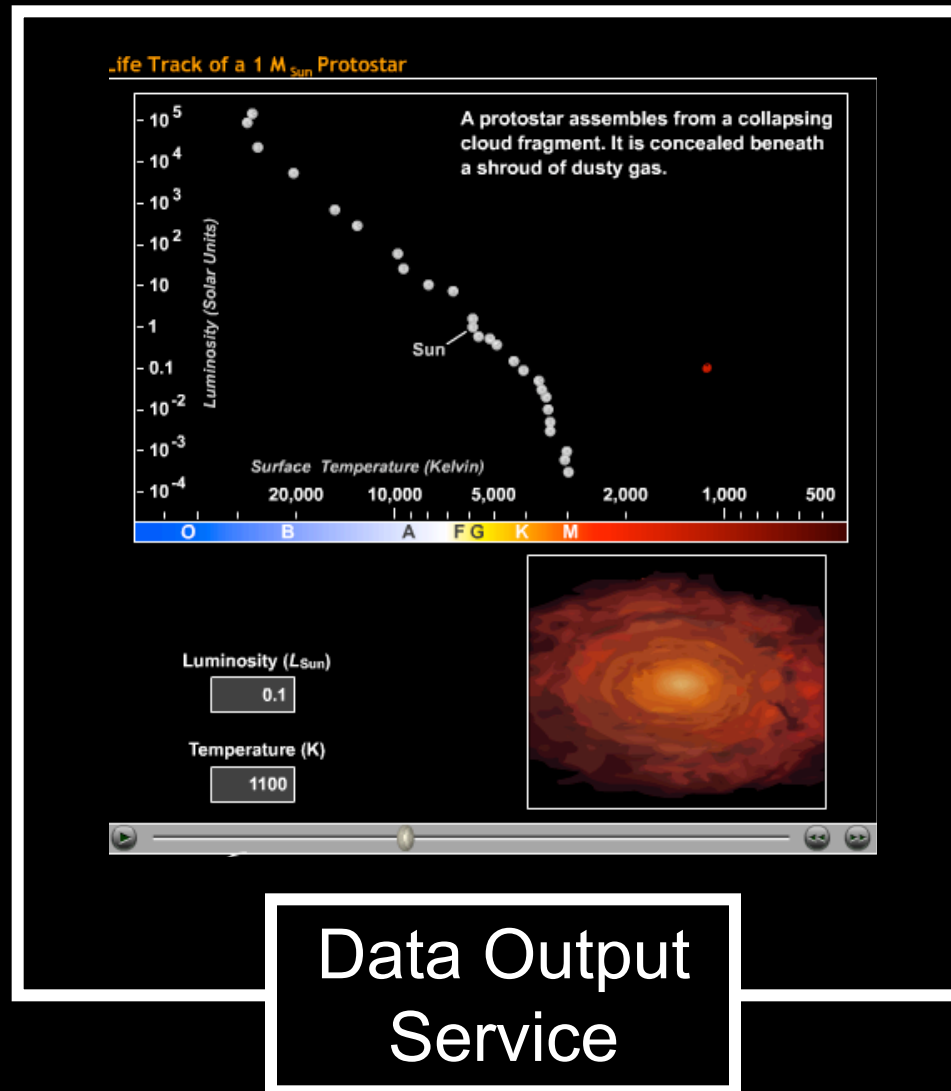
Part C

At the falling rocket plunges toward the event horizon, an observer in the falling rocket will see her own clock running _____.

☐ increasingly faster
☐ at a constant, normal rate
☐ increasingly slower while never quite stopping
☐ increasingly slower until coming to a stop at the event horizon

Submit Answer Flag question Give up Reveal part

Student Pitfalls with Interactive Tools

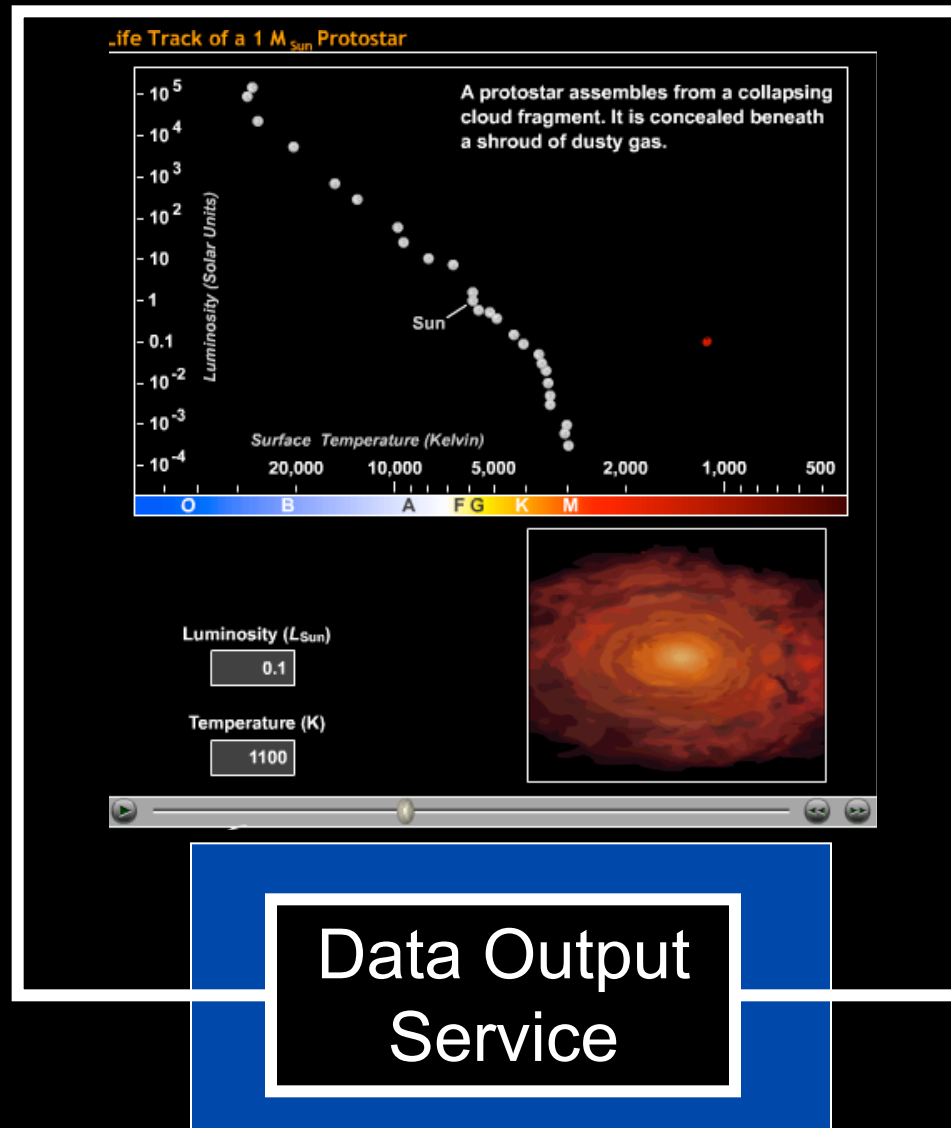


Students implicitly trust “truth” of the interactive tool!

No concern for developer ...

- Deceit
- Error in understanding
- Error in implementation.

Student Pitfalls with Interactive Tools



By comparison ...

Students readily point out discrepancies between numerical output and their expectations as computer error!

Student Difficulties with Visual Activities

STP

Visual Activity: Phases of Venus

Difficulty: 1

Time: 9m

Action: (select action)

Visual Activity: Phases of Venus

Intro 1

Phases of Venus



Part B

In the Earth-centered model of the solar system, Venus never appears opposite the Sun in our sky, and the distance between Venus and Earth does not change very much. Given that the Sun (and not Earth) is really at the center of our solar system, which of the following statements is true?

- ☐ Venus never appears opposite the Sun in our sky, and the distance between Venus and Earth does not change very much.
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[submit](#) [hints](#) [my answers](#) [give up](#) [review part](#)

Part C

When would a new Venus be high in the sky?

- ☐ noon
- ☐ sunset
- ☐ midnight
- ☐ sunrise

[submit](#) [hints](#) [my answers](#) [give up](#) [review part](#)

Part D

Which phase of Venus would you expect to see high in the sky at midnight?

- ☐ waxing gibbous
- ☐ waning crescent
- ☐ full
- ☐ No phase is visible since Venus is *never* high in the sky at midnight.

[submit](#) [hints](#) [my answers](#) [give up](#) [review part](#)

Part E

Knowing that Venus always appears relatively near the Sun in our sky, which phases of Venus can only occur

Avoidance of the Interactive Tool
Opportunity for “learning to learn”?

Student Difficulties with Visual Activities

STP

Visual Activity: Phases of Venus

Difficulty: 1

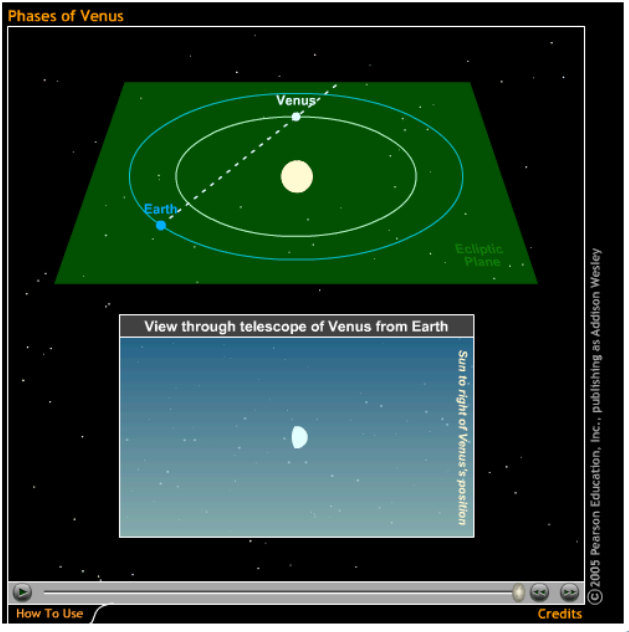
Time: 9m

Action: (select action)

Visual Activity: Phases of Venus

Intro 1

Phases of Venus



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Part B

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Part E

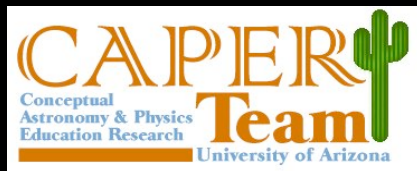
Knowing that Venus always appears relatively near the Sun in our sky, which phases of Venus can only occur

Accustomed to no-cost/low-cost penalties for incorrect answers

Visual Activities for Assessing Non-science Majors' Understanding in Intro Astronomy



Daniel Loran
Truckee Meadows Community College
dloranz@scs.unr.edu



Edward E. Prather
& Timothy F. Slater
University of Arizona