

The Wonders of Physics 2013

Checklists:

Marty: insulating stool in sink. Water in electrolysis, turn on before show. Water in milk jug. Fluorescent bulbs backstage. Rod and cloth backstage. Van de Graff generator plugged in.

Ed: water beaker atop red silk; rotating platform leveled and place; enough gas left in CO2 tank; have Mic #3 prior to show; have vacuum tube backstage prior to doors closed.

Opening (Peter [Mic #2] , Sprott [Mic #1]):

Look up Demos: <http://www.physics.wisc.edu/facultywiki/Demonstrations>

[NASA Curiosity Mars Rover](#) - 7 pages of fun.

(ON B) - **RGB {T2 G1}**: **Intro PPT Slide Shows**

Audio: Science Songs

(ON A&C) - **Cameras 5 & 6: {Crowd Shots on A & C }**

{Mute all as Peter walks out}

(ON B) - **RGB {T2 G1}**: **[Panorama of Mars Landscape](#) {on the front screen}**

Peter: Welcome to the (248, 249, 250, 251, 252, 253, 254, 255, 256, 257) presentation of *The Wonders of Physics*... Before the show begins, I would like to assure you that we make all of our demonstrations as safe as possible provided you remain in your seats.

For the past 30 years, we Martians have enjoyed watching The Wonders of Physics on our televisions, broadcast from Earth transmissions. As your King of Sprottania I have invited Professor Sprott to visit us here on Mars and show us some of his favorite demonstrations. I believe I can see him approaching now. Niner Alpha Victor you are cleared to land....

[Turn On] - **PPT Slide show Audio - From 2nd RGB line by sending "Lectern Video 1" to "Muted" Projector A or C**

(ON B) - **RGB {Lec G1}**: **PPT SLIDES - [Intro Movie Clip](#)**

And here he comes, straight from his debut performance at the Sultan of Brunei's castle. Yours and my favorite Earthling. Proffessoorrrrr.... Sprotttt..

Audio: [WOP Theme-Short](#)

{Sprott enters stage right in a space suit on the Mars Rover coming down a steep ramp with pyrotechnics and the thrusters firing in reverse to slow him to a stop at stage center.}

Sprott: Welcome to *The Wonders of Physics*. We've been to Portugal, South Africa, Egypt, and Japan, but this is our first visit to Mars, and I'm delighted to celebrate our 30th season here. I'm glad to see you have prepared an atmosphere that I can breathe *{hands space helmet to Peter}*. I see you've also prepared the demonstrations I requested as well as some of your own.

Peter: Yes, I'm Peter Weix, King of Sprottania, which we named in your honor, and it's a pleasure to welcome you here. (Vulcan Salute) We've learned from you that there are six major areas of classical physics ([Slide: Classical Physics](#)). Could you please show me your favorite demonstration of the Physics of Motion?

(ON B) - RGB {Lec G1}: PPT SLIDES - Classical Physics

Sprott: Asking for a favorite demonstration is like asking a parent which is their favorite child. I like them all, but I can do one that is very popular back on Earth if one of you Martians would volunteer to help...

{Peter puts the rocket lander away, and walks around behind the benches to stage right leaving the space helmet on the bench center.}

Demo: [{Bowling Ball Pendulum, 1M40.10}](#)

Audio: [slidewhistle-down-up](#)

Audio: [Ta-Da-1](#)

Audio: [Ta-Da-Formal](#)

Sprott: On Earth, our gravity is almost three times stronger than what you have here on Mars, and so our bowling ball swings about 60% faster.

Since my muscles are used to Earth's gravity, I can jump quite high here on Mars. Let me ask King Weix to attach this rope just in case something goes wrong...

Demo: [{Mars Gravity Simulator \(pulley in ceiling with 100 lb counterweight on block and tackle\)}](#)

Audio: [Ta-Da-1](#)

Audio: [Ta-Da-Formal](#)

Peter: Well Professor Sprott, I see you are enjoying our weak gravity here on Mars. We have a scientist who is devoting great effort in the study of motion and he would like to demonstrate some of his findings. I introduce to you, the talking physicist, Mr. Ed!

[Ed turns on Mic #3 and enters via stage left door.]

{Ed's Introduction; he enters with already evacuated tube.}

Audio: Sprott makes horse sound!

Motion (Ed [Mic #3]):

Ed: Greetings, Earthling Sprott! It is a pleasure to meet you! The Martian High Command thought you might like to meet me, since you are an avid dancer **[Slide: Sprott]**.

{Sprott does a little dance.}

Ed: Well that's pretty good; I've been working on a few moves myself!

{Ed busts a move; does some kind of toe-dance like Elvis.}

(ON B) - RGB {Lec G1}: PPT SLIDES - Sprott

(ON B) - RGB {Lec G1}: PPT SLIDES - Elvis

Ed: I'm still learning, but I learned that from your late Earth King after he moved here in the late seventies, Elvis Presley! **[Slide: ELVIS]** Of course, we also like other kinds of motion as well! I've prepared three of my favorite motion demonstrations for you to enjoy: one for each of straight-line, circular, and non-motion.

Start Demo: {Guinea and Feather Tube}, 1C20.10

Ed: As you can see here I have a glass tube with a cotton ball and a penny that Curiosity brought with it. I opened this valve outside, so the atmosphere inside is that of Mars. This means that there's only about 1% the amount of air in this tube as there would be on Earth! As you can see when the tube is flipped, **{Flips tube}** the cotton ball and the penny fall at the same speed here on Mars since there's hardly any of that pesky air in the way! **{Flips tube once or twice more to elaborate.}**

Ed: Now, just by opening this valve, we can see that the atmosphere of this room will bleed into the pipe **{Opens valve with cotton ball on valve-end such that the cotton ball floats.}** The cotton ball being blown by the incoming air shows how empty this tube really was! Now, with all of those menacing air particles in the way...**{Flips tube}** the penny is the clear winner!

END Demo: {Guinea and Feather Tube}, 1C20.10

Audio: Ta-Da-1

{Ed puts down glass tube and pulls rotating platform and leafblower out from

under the front table.

Starts Demo: *{Rotating platform}*, 1Q40.10 - ***{ With Leafblower}***

Audio: *Merry go Round*

(ON B) - RGB {Lec G1}: PPT SLIDES - Newton

Ed: Now that we've looked at straight-line motion, let's look at some circular motion! ***{Stands on level rotating platform with CO2 can in hand.}*** If I stand here and nothing causes me to move, I don't move! This is Earthling Isaac Newton's **Slide: NEWTON** first law in a nutshell; if there's no force, an object at rest, STAYS at rest; an object in motion STAYS in motion! Now, Newton's second law tells us that if a force acts on me with no force to push back against it, I'll start to spin! Dr. Sprott, would you give me a start?

{Ed extends his arm and Sprott gives it a push. Ed spins. (CO2 can still in hand.)}

Ed: Thanks, Dr. Sprott. Now that I'm spinning, I should try to figure out a way to stop! Your rocketship gave me a good idea about how to do this. I'm going to use this small rocket to push a bunch of air molecules in the opposite direction of how I'm moving. This is Newton's Third law of motion: equal and opposite forces! ***{Ed blasts CO2 such that he eventually comes to a stop.}***

Audio: *Ta-Da-1*

Ed: ***{Maybe while either pretending (or actually being) dizzy}***

Demo: *{Beaker and Tablecloth}* 1F20.30 *{Ed pulls the silk out from under the beaker}*

Ed: Now, I've seen a lot of Earth "magicians" do this "trick" on Earth. Here I have a beaker of Mars water atop a red cloth; my goal is to pull the cloth out from under the beaker with spilling it--it's rare stuff, after all. How do you guys think I should try it? ***{Ask audience and listen for responses; ultimately, go with → }*** Okay! I'll try it slowly first because I'm nervous. ***{Pull cloth slowly--nothing happens.}*** Well, that didn't work, I guess I could try it differently. Give me some noise to help me out! ***{Pull cloth quickly; it works.}***

Audio: *Ta-Da-1*

Ed: Well thanks for coming to Mars, Dr. Sprott! I must be off now because I'm a judge for this year's Dancing with the Martians!

{Ed Gangnam's out the door.}

Audio: *TA-DA-Proud-2*

[Ed, Mute Mic #3 and hand it to Mike Randall]

Peter:

Peter: Well Professor Sprott, as Mr. Ed goes to burn up the dance floor, did you happen to notice how cold it was outside? We Martians just love it because we can ice skate all year around. But I understand that it is much warmer on Earth. Do you have a favorite heat demonstration you can show us?

Sprott: It is much warmer back on Earth than here on Mars, but let me show you something that's colder than even your coldest winter night...

Demo: {Liquid Nitrogen Cannon}

Audio: [NitrogenCannon.wav](#)

Audio: [Ta-Da-Formal.wav](#)

Audio: [Ta-Da-1](#)

Heat and Pressure (Michael [Mic #4]):

{Michael enters, dressed as a Martian....}

Michael: Well that went off with a bit of a bang! If I heard correctly, you were talking about heat. I am the Martian Steward of Land, Wind and Water and I am all knowing when it comes to things hot, cold and in between.

Sprott: Land and wind, sure, but water....I don't see and lakes or rivers here.

Michael: Shhhh.....please don't mention that to the King. He is still very, very angry at my predecessor for what happened to the water. Perhaps your Earth will be more fortunate. We still have a few princely things on Mars. We have the tallest known mountain in the solar system! It's an extinct volcano called **Olympus Mons**. It is **three times** as tall as Mount Everest thanks to our weak gravity.

(ON B) - RGB {Lec G1}: PPT SLIDES - Olympus Mons

{Show picture of Olympus Mons}

Michael: Dear Professor Sprott, you have performed many demonstrations that our Martianettes (Martian children) have enjoyed. A few of them have braved your dense atmosphere to be here. Some are quite shy.

They have been collecting a colorless, odorless gas methane which is sometimes emitted by active volcanoes on Earth. We have a demonstration here which will allow

to explore the properties of methane gas. Ad lib....

Demo: {Exploding soap bubbles}

Audio: [Ta-Da-Formal.wav](#) [Ta-Da-1](#)

Michael: On your planet the gas methane is a powerful greenhouse gas. Mars could use more of that because the air temperature is always below freezing! In fact all of the water is trapped as ice beneath the crust. It is easy to freeze water on Mars. Here is what happens to water if we reduce the air pressure to be that just outside. Ad lib.

Demo: {Freezing by evaporation}, 4C31.20

Audio: [Ta-Da-1](#)

Michael: Water also appears in a gas phase. Would any child here know the common name for the gaseous form of water. (Steam). So, in this drum we are boiling liquid water to create steam. The steam will fill the can. We then seal the can and, upon cooling, the steam will condense back to liquid water and reduce the “air” pressure inside the can. The Earth like air pressure will crush the can. Sadly, this demonstration doesn’t work outside.

Demo: {Collapsing Can}, 2B30.15: {[Atmospheric Pressure](#)}

Audio: [Ta-Da-1](#)

Michael: Mars used to have an atmosphere but we lost it to outer space. Now it is less than 1% of that on your Earth’s surface. So many of your best Wonders of Physics demonstrations don’t work outside the pressure dome. Oh what Martianette wouldn’t give his little green eye teeth for a real atmosphere. Earthlings are so lucky.

I have one more demonstration that requires an Earth-like atmosphere. For this I will need a volunteer to crush this can ofMartian Dew with.....a ping pong ball. Ad lib....

Demo: {Ping Pong Ball Bazooka}

Audio: [Ta-Da-1](#)

Michael: Well I’m **crushed** that my time is up. We have more work to do at Mount Olympus monitoring some rumbling sounds. Maybe its not so extinct...

Audio: [Rumble](#)

Audio: [TA-DA-Proud-2](#)

[Michal, Mute Mic #4 and hand it to Marty]

Peter:

Peter: Our Steward of Land sure is a noisy fellow. I really don’t like all of this loud noise. Due to our lack of atmosphere it sure is nice and quiet outside. I don’t know how you

Earthlings can stand it with all of those noisy birds and animals around. Do you have a favorite sound demonstration, preferably one that isn't so loud?

Sprott: We do have lots of sounds back on Earth, and sometimes it can be very annoying. Sound is a wave, and normally it's invisible, but there is a way to show what it would like if you could see it...

Switch RGB lines

(ON B) - RGB {T3G1}: Oscilloscope

Demo: {Oscilloscope Waveforms}

- **Tuning Fork**
- **Recorder**

Audio: [Ta-Da-1](#)

- **Whistle**
- **Dog Whistle**

Audio: [Dino Bark](#)

Audio: [Ta-Da-1](#)

Switch RGB lines back

(ON B) - RGB {Lec G1}: PPT SLIDES - Black

Sound (Mike [Mic #3], Dan [No Mic]):

Audio: [FlyMeToTheMoon-15s.wav](#) -- { AT LOW VOLUME }

Sprott: Is that singing I hear? That can't be because the atmosphere here is so very thin.

{Mike Randall enters, sound still playing, but him not visibly singing}

Mike: My apologies! I'm Mike, the Minister of Sound. I'm so excited to meet the Great Sprott, I forgot to move my lips! Sound works very differently here on Mars, so we Martians usually communicate directly with our brains. We've learned to move our lips to make you Earthlings more comfortable.

Sprott: Sound is one of my favorite physics subjects. Please tell me more.

Mike: We have learned that sound is a vibration travelling through some material.

Mike: You can't usually see sound, so I'm using this coiled wire to demonstrate. Earthlings call this a "slin-kee". In a sound wave, the material is pushed together, then spread apart. This is called a longitudinal wave.

Demo: {Hanging slinky}

{Pause}

Audio: [Ta-Da-1](#)

Mike: Sound depends on pressure, temperature and the material that it is moving through. On Earth, the atmosphere is mostly Nitrogen and Oxygen. Earthlings call this mixture “air”. Sound travels through air at about 340 meters per seconds - that’s over 760 miles per hour!

Mike: The frequency of sound is how many sound waves pass a point in a given time. Earthlinks know this as “pitch”. I’ve created this device to help demonstrate. I call it a “Barsoom”.

The pitch produced by the Barsoom depends on its length, and the density of the gas inside. When you blow air through the Barsoom, it sounds like this

Demo: {Wood whistle with air}

Mike: However, the speed of sound in helium is almost three times faster! The sound waves bounce back and forth in the Barsoom faster, more waves come out in a given time - which means a higher pitch!

Demo: {Wood whistle with helium}

Mike: Sulfur hexafluoride, or SF₆, is a very dense gas. The speed of sound in SF₆ is only about one-third that of air! The sound waves bounce back and forth in the Barsoom more slowly, fewer waves come out in a given time, making a lower pitch. [You could have a slide showing the gases and the speed of sound in them.]

Demo: {Wood whistle with SF₆}

Mike: Here on Mars, the atmosphere is almost completely made of carbon dioxide. Listen carefully!

Demo: {Wood whistle with CO₂}

Audio: [Ta-Da-1](#) -- [When done with Barsoom!!!]

Mike: What do you think the speed of sound is in our atmosphere? Right! Carbon dioxide is more dense than air, but less dense than SF₆, so the pitch from the Barsoom was a little lower than for air.

Mike: I mentioned earlier that sound works very differently here on Mars. To demonstrate this, I have a sample of the martian atmosphere inside this jar, along with a

sound generating device. Oh! I also want to introduce you to my pets, Phobos and Deimos, named after Mars' moons.

Mike: The martian atmosphere is very thin, so sound fades away quickly. Listen to this Earth music.

Demo: {Bell at vacuum}

Mike: You can barely hear it! But Earth's atmosphere is over 140 times as dense! I'm now going to let the air into the jar. Listen to the difference!

Demo: {Bell at normal pressure}

Audio: Ta-Da-1

[Turn On] - PPT Slide show Audio - From 2nd RGB line by sending "Lectern Video 1" to "Muted" Projector A or C

Mike: It got much louder! Now you know why we Martians don't usually talk! Even if we shouted, we'd have to stand within a few feet of each other to be heard.

{A Martian girl wanders in carrying a large apple and speaking into it in Martian jibberish.}

Mike: What are you doing?

{speaking in Martian jibberish, but with a slide showing the English translation}

(ON B) - RGB {Lec G1}: PPT SLIDES - Martian to English translation w/sound file

Audio: Martian-1.wav

Dan: *I'm using my apple computer to translate from Martian to English. {Scrolls Across PPT}*

Mike: That's not an Apple Computer!

{still speaking in Martian jibberish, but with a slide showing the English translation}

(ON B) - RGB {Lec G1}: PPT SLIDES - Steve Jobs holding an apple w/sound file

Audio: Martian-2.wav

Dan: *Yes it is! Steve Jobs {slide of Steve Jobs holding an apple} was working on it just before he died, and he sent me the plans by email. {Scrolls Across PPT}*

Mike: That's a nice invention, and it will certainly help us communicate with the Earthlings.

{Dan exits.}

Audio: [TA-DA-Proud-2](#)

Sprott: Let me try some of that telepathic singing you were doing.

{Play audio of Sprott singing Holst's MARS}

Audio: [Holsts-Mars-15s.wav](#) --{ LOUD!! }

Mike: Oh no, not MARS by Holst, that tune is so played out here! I've got to go.

{Mike Randall exits}

Audio: [TA-DA-Proud-2](#)

[Mike, Mute Mic #3 and hand it to Blaine]

Peter:

Peter: You know professor Sprott, that was really a Mapple computer that he was showing you. Our technology has exploded over the past decade, we now have M-pods, M-phones and M-pads. But this has all come at a great expense to our electrical grid and are now suffering with rolling black-outs. Why do transformers hum? **They don't know the words.** Could you please show us one of your favorite Electricity demonstrations?

Sprott: We have lots of electrical devices back on Earth. In fact, we sometimes have electrical discharges in the air, and I can demonstrate that if one you Martians would volunteer to help...

Demo: *{Faraday Cage w/Tesla coil}*

Audio: [Doom-March](#)

Audio: [Shocking](#)

Audio: [TA-DA-Proud-2](#)

Electricity (Marty [Mic #4]):

{Marty enters stage right}

Marty: Greetings O! Great and Wonderful Sprott of Wisconsin. I am, Martin the Martian, the Secretary of Energy of Sprottania!

Sprott: Hello Martin the Martian.

Marty: It is my job to make sure we have enough electricity so that every Martian can watch the Wisconsin Public Television broadcasts of the Wonders of Physics. Your demonstrations are electrifying! I was inspired by your Tesla coil to see if we could transmit electricity through the air!

(ON B) - RGB {Lec G1}: PPT SLIDES - Tesla

Sprott: Actually, that was one of Nikola Tesla's early ideas. **[SLIDE OF TESLA]** He wanted to make a very Tesla coil and send power all around the Earth without wires.

Marty: Let's show everyone how. We'll take these fluorescent bulbs and have a few of our fellow Martians hold them, and I'll take one here. Now if you'll be so kind as to fire up the Tesla coil again.

Demo: [{Tesla coil}](#)

Audio: [Ta-Da-1](#)

Marty: As you saw, the bulbs lit up, even though they were not connected directly to anything.

Sprott: That's right, the electric discharge creates electromagnetic radio waves, and the bulbs act like antennas and receive that energy.

Marty: The Tesla coil takes a lot of power though, and we needed a way to create that electricity. We found that you can create static electricity by rubbing a of insulating plastic with a cloth. Electrons rub off the cloth onto the plastic, charging it up. When we bring it near another insulator like this paper, it presents an opposite charge and the paper is attracted.

Sprott: In electricity, opposites attract.

Marty: We can use this method of generating electricity over and over again with a moving cloth, in a Van de Graaff Generator. **[SLIDE OF VAN DE GRAAFF]**

(ON B) - RGB {Lec G1}: PPT SLIDES - Van de Graaff

Demo: [{Van de Graaff Generator}](#)

Audio: [TA-DA-Proud-2](#)

Marty: We used to have great streams of liquid water on Mars. That's all dried up and frozen now, but we used to use the water to conduct electricity.

Demo: {Conductivity of water}

Audio: [Ta-Da-1](#)

Marty: And we can actually put electricity into the water to make fuel for our space ships!

Demo: {Electrolysis}

Audio: [Ta-Da-1](#) ⇒On the H gas

Marty: I've got to go make sure our generators are running! Please say hi you YOUR secretary of energy, Nobel Prize winning physicist **Steven Chu!**

(ON B) - [RGB {Lec G1}: PPT SLIDES - Steven Chu](#)

{Marty exits}

[Marty, Mutes Mic #4 and hand it to Kenny]

Audio: [TA-DA-Proud-2](#)

Peter:

Peter: What did one magnet say to the other? I find you very attractive. Well professor Sprott, we have experimented with magnetism, in fact we developed the first ever magnetically levitated train, but it was not very successful, due to our weak gravity it is difficult to keep the train on the tracks. What is your favorite demonstration of magnetism?

Sprott: Magnetism and electricity are very closely related. In fact, one way to make a magnetic field is with an electric current...

Demo: {Jumping Ring}

Audio: [Ta-Da-1](#)

Audio: [Charge](#)

Audio: [Fanfare](#)

Magnetism (Blaine [Mic #3]):

Blaine takes mic from Mike Randall.

Blaine enters to a short clip of Orff's Carmina Burana

Blaine: (in booming voice) "Salvete! Meus nomen Mars est, Deum Belli. Quomodo sunt?"
(to stage right): "...Que? They don't speak Latin anymore? It's been awhile since I've

spoken with Earthlings.”

(to audience): “Well, this is awkward! It has been brought to my attention that you all no longer recognize the Roman pantheon of gods, so I suppose we can lose the formality. I’m Blaine, the head scientist for the R&D group at the Martian Department of Defense. Our technology was so advanced when we met with the Roman Empire that they deemed me a god!

One of the technologies we introduced to the Empire was a pharmaceutical compound to enhance soldiers' abilities. Here on Mars we call it Martian Dew, a refreshing beverage stock full of sugar, caffeine, and magnetic energy. It is the stored magnetic energy that makes this compound so effective; would you like to see how we do it?”

[Blaine: The Can Crusher is now “Fixed” and will hold it’s charge until you release the button...]

Demo: [{Can Crusher}](#)

- **Crush Can**

Audio: [Ta-Da-1](#)

Blaine: “I have been informed that you Earthlings have only recently invented something similar, a drink known as ‘Red Bull.’ They say it gives you wings, but Martian Dew can *really* fly! You sir, get ready to catch the can. The rest of you may want to be ready too, this can be a little unpredictable!”

- **Lunch Can into Audience**

Audio: [Ta-Da-1](#)

(ON B) - RGB {Lec G1}: PPT SLIDES - Lorentz

“This device works to crush the can by using something known as the Lorentz force. **[SLIDE OF LORENTZ]** This capacitor stores 4 kV of potential, and then discharges it all at once. The current runs through these copper coils, where it creates a magnetic field. The interaction between the induced magnetic field and the flowing current create a force that pinches the can inward. When we place the can a certain way, some of this pinching force can be used to give it a trajectory, so we can launch the can. A similar concept is used on US Naval ships to launch projectiles very far!”

(If we can use ferrofluid I will add the following script)

Demo: [{Ferrofluid and Magnet}](#)

Blaine: “Magnetic fluids are very interesting, and research relating to plasmas is helping humans understand how stars behave and how nuclear fusion may provide a relatively safe, clean source of energy in the future.

Audio: [Ta-Da-1](#)

Demo: [{Levitated ball}](#)

Blaine: “You may know that Roman soldiers built extensive roads through the Empire during peaceful periods. This expansive network of roads helped commerce, transportation, and the exchange of culture and information. With a modern understanding of magnetism, Earthlings and Martians have built transportation like the MagLev, which allows for much faster transportation. Unlike a conventional train, the MagLev floats above the tracks. In this manner, it eliminates the resistive force that is due to friction, so it can achieve faster speeds with less energy. Would you like to see how magnetism can be used to levitate objects?”

Audio: [Ta-Da-1](#)

Demo: {Eddy Current Copper Plates}

Blaine: “You may be wondering how you get something like the MagLev to stop if there is no friction to use for braking. As it turns out, we can use magnetism for that, too! You see, nature doesn’t like a changing magnetic field, and will induce eddy currents to resist the change. As this magnet moves, it creates a changing magnetic field, which in turn makes eddy currents. Since the magnet is moving *toward* the conductor, the induced current creates a force to push it *away from* the conductor. The net effect is to slow the magnet as it drops. This is the way that roller coaster cars are slowed at the end of the ride. It is also why you sometimes see a spark when you quickly unplug something from your wall outlet.”

Audio: [Ta-Da-1](#)

Blaine: Well, that’s all I’ve got time for now; I have to go plan my invasion of Venus!

{Blaine exits}

[Blaine, Mutes & Hands off Mic #3 as fast as possible to Bethany]

Audio: [TA-DA-Proud-2](#)

Peter:

Peter: How many theoretical physicists specializing in general relativity does it take to change a light bulb? Two. One to hold the bulb and one to rotate the universe. Well Professor Sportt, one thing that I really love to do, is go outside at night and look up at the stars. Can you see stars when you are on Earth?

Sprott: Just like here on Mars, when we look up at the sky at night, we see stars, but our stars often appear to twinkle. Let me show you what that means and why it happens...

Demo: {Twinkling Stars}

Audio: [twinkle-twinkle-little-star-piano.wav](#)

Audio: [Ta-Da-1](#)

Light (Kenny [Mic #4], Bethany [Mic #3]):

Kenny: Welcome, Sprout the Magnificent! We are the officers of the Martian Light Brigade.

Bethany: It is our job to study how to do things with light! We have found your demonstrations to be most illuminating. Allow us to show some of what we have learned about light.

Kenny: When we shine a light, like a laser, what's the trajectory, or path, that the light takes? In your last demonstration, the laser beam traveled in a straight line. Is this always so?

Bethany: Hey guess what?! I just saw a really neat device that can answer your question, and we have one right here!

Demo: {Light guide}

Audio: [Ta-Da-1](#)

Bethany: What we're witnessing is called *total internal reflection*. If the laser hits the inside surface of the plastic tube at the correct angle, it will not pass out of the tube, and instead be reflected, staying inside the tube! That's why we call this a light guide, as it guides the light from one end of it to the other.

Kenny: We can even use this principle for communication; this is how fiber optics works, which is one way that internet, cable TV, and phone signals can travel from place to place.

Bethany: Now, one day, I was looking at Earth through my telescope. I saw some lovely signs all lit up. I found out I was looking at *neon lights* and decided to make some for myself. These lights are also called *Geissler tubes*; **[SLIDE OF GEISSLER]** each is filled with a gas, such as neon.

(ON B) - RGB {Lec G1}: PPT SLIDES - Geissler

Kenny: When an electric current is run through the gas, the electricity excites the atoms in the gas, causing them to glow! Take a look!

Demo: {Geissler tubes}

Audio: [Ta-Da-1](#)

Bethany: From watching Earth television (**Kenny:** -not too much- it'll rot your brain, kids!), we've learned that your [directed at Sprott] sky is blue. Why do you think this is?

(ON B) - RGB {Lec G1}: PPT SLIDES - Reyleigh

Kenny: The light that comes from the sun is white- all colors combined. However, when this white light hits the atmosphere, something called Rayleigh scattering happens.

[SLIDE OF LORD REYLEIGH (JOHN STRUTT)] Some of the light passes straight through the atmosphere, while some of it bounces around off of particles in the sky. The red and yellow light come straight through, while blue light bounces around more.

Bethany: When you look at the sky, you're seeing the blue light that has bounced off particles in the sky. When you look at a sunset (**Kenny:** -never directly at the sun!), the light has bounced around much less and looks redder! We can demonstrate this here!

Demo: {Rayleigh scattering}

Audio: [Ta-Da-1](#)

Bethany: Now, our sky on Mars is a butterscotch color. This is because our atmosphere is much thinner than Earth's, and we have more dust particles in it.

{Show picture of Martian Sky, e.g.: }

(ON B) - RGB {Lec G1}: PPT SLIDES - Martian Sky

Kenny: Who likes to pop balloons? On Mars, we like to pop balloons too!

Bethany: But it's too easy to pop a balloon by sitting on it. We're going to pop a balloon with a laser!

Kenny: And what's more, we're going to pop a balloon inside another balloon, without popping the outer balloon!

Audio: [Phaser.wav](#)

Demo: {Laser Balloons}

Audio: [TA-DA-Proud-2](#)

Kenny: We've been *de-lighted* to share our knowledge with all of you. Now we must go. Light Brigade, charge!

{Kenny & Bethany exits} [Kenny & Bethany, Mute Mics and return them to me!]

Audio: [TA-DA-Proud-2](#)

Closing (Sprott, Cast):

Sprott: It has been a pleasure to visit Mars and to see what you have learned from watching The Wonders of Physics all these years. As you know, we have always ended our shows on Earth by making a cloud **[SLIDE OF CLOUD (FROM PAST YEARS PPT ENDING)]**, something you don't have here on Mars, but they are beautiful white puffy things that hover in the atmosphere. And I can show you how they are made using this demonstration...

Demo: {LN2 Cloud}

(ON A & C) - RGB {Lec G1}: PPT SLIDES - Thank you

(ON B) - DVD Video: [Theme music video](#)

Audio: [WOP Theme-long-3m22s.wav](#)

{The show concludes with Sprott disappearing in the Liquid Nitrogen Cloud. [Theme music video](#) plays. Cast enters stage left and bows in unison.}

Miscellaneous Notes:

See [list of demos](#) we have done in previous years for other ideas.