Intro:

Q-B - RGB {T G1}: Into PPT Slide Shows
Audio: Science Songs
Cameras 5 & 6: {Crowd Shots on A & C }

{Mute all as Peter walks out}

Peter: Welcome to the (223, 224, 225, 226, 227, 228, 229, 230, 231, 232) 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. Prof. Sprott has asked me to find someone to entertain you until he arrives, so I found a story-teller on State Street. Please give a warm welcome to Reid Miller...

{Reid comes on stage with a duck puppet and tells some duck jokes, managing to injure the duck in the process. -- 1-2 minutes}

Audio: Duck ***{as Reaid comes on the stage}***
{and at all the bad Jokes}

Reid: I think we need a doctor to fix this duck. Is there a quack doctor in the house?

{Sprott enters through a side door in disguise}

Sprott: In come I that never cometh yet,
The best Doc Quackter you may bet.
Here I come from the Continent
To cure this duck which Reid Miller hath slain…

Reid: And how did you come to be a doctor?

Sprott: By my travels.

Reid: Where have you traveled?

Sprott: I've been to Icky Picky, France, and Spain,
Three times to Oconomowoc,
And now I've returned to Madison again.

Reid: What can you cure?

Sprott: All sorts.

I can cast out 14 devils from one's heart.
I can cast 21 out.

Reid: Well then, cure this duck.

Sprott: Here, Duck, take three sips at this bottle,
Down thy thrittle throttle,
And arise and quack some more.

{Reid slumps over as if dead}

Reid: I think you've killed him!

Sprott: Oh Reid, I quite forgot,
I took the wrong cork off the right bottle,
The right bottle off the wrong cork.
But in my inside outside backside pocket, I have another bottle.
In it there is some hokey pokey snokey;
And it's sure to bring a dead duck back to life.
If you don't believe these words I say,
Step in Dairy Dout, and clear the way.

{Dairy Dout enters in oversized WoP shirt while Sprott turns his back to the audience and removes his disguise.}

Dairy Dout (Cassie Narf):
In comes I, little Dairy Dout,
With my shirt lap hanging out,
Five yards in and five yards out.
Out goes little Dairy Dout.
{She gives Reid the antidote}
If you don't believe these words I say,
Step in, Professor Sprott, and clear the way.

{Dairy Dout and Reid Miller exit, while Sprott pivots around}

Audio: WOP Theme-Short
Q-B – Lectern Computer 1 {2011WOP-Slides.ppt}: "Play"

Sprott: Welcome to *The Wonders of Physics*. I have always wanted to be an actor and even played the Quack Doctor in Mummer's plays
RGB: {PPT SLIDE 1: Play}, but I have nightmares about being in a play and completely forgetting my lines. That's one reason I went into physics, because we like to figure things

out from basic principles rather than memorize them. But this is the Year of the Arts at the University of Wisconsin

RGB: {PPT SLIDE 2: Year of the Arts}, and so I thought we should discuss Physics of the Arts, and maybe find an art that's more suitable for me. Peter has lined up some special guests to help explain what physics has to do with the arts. Peter, who's on first?

Peter: Yes, Who's on first, What's on second, and I Don't Know is on third.

Sprott: Who's on first?

Peter: Yes, Who's on first, What's on second, and I Don't Know is on third. But we did baseball last year… Motion is an important area of physics, and so I found a dancing scientist who recently appeared on *America's Got Talent*. Give a welcome to Jeff Vinokur…

Audio: Sound Track to Dancing with the start

{Sprott sits at an artist's easel painting while others do their demos.}

Motion (Jeff Vinokur): *Dance*

{Enters with fire extinguisher on a skate board.}

Audio: Intro

Demo: {Fire Extinguisher W/Skate Board}

Audio: Ta-Da

Vinokur: Welcome ladies and gentlemen! My name is Jeffrey Vinokur and I am a real life dancing mad scientist! I am here to tell you all about how the physics of motion plays such a big part in the arts.

Q-B – Lectern Computer 1 {2011WOP-Slides.ppt}: "Newton"

Vinokur: What I have here is a fire extinguisher filled with carbon dioxide gas. I used a skateboard to make it easier to slide, and then I just shoot carbon dioxide gas to propel me into motion!

Vinokur: A physicist named ***Issac Newton***

RGB: {PPT SLIDE 3: Newton} explained this through his third law of motion which says that for every action there is an equal and opposite reaction. For example if you were to stand next to your friend and push them really hard (not recommended), your friend will go in the direction you pushed them and you will feel a force going in the opposite direction. That is Newton's third law of motion!

Q-C - Camera 6: On Stage for "MoonWalk"

Vinokur: Did you know that Newton's third law can also help you do the moonwalk?

Camera 6: On Stage for "MoonWalk"

Hit it DJ!

Audio: MoonWalk

Audio: Ta-Da

Vinokur: That was fun, but I have some even more interesting physics to show you today. What I have here is an "Airzooka:" It's a children's toy that shoots rings air vortex rings! I'm going

to shoot some air into the audience and if you feel a gust of wind go by, just raise your hand. ***(Shoot air into audience).***

Demo: {AirZooka}
Audio: Ta-Da

Vinokur: Now, I was thinking, wouldn't it be even cooler if we could see these air vortex rings? That is why I brought a fog machine with me. OK, let's try this... ***{Que: Ghost Busters Theme Song. Shoot rings into audience.}***

Audio: Ghost Busters
Audio: Ta-Da

Q-B – Lectern Computer 1 {2011WOP-Slides.ppt}: "Torus"

Vinokur: Wasn't that awesome?! The physics here is pretty amazing too. A vortex is simply a fluid that is swirling, good examples are tornadoes, hurricanes and whirlpools and it all comes down to the physics of motion. When air moves really quickly out the hole in the front, the air on the sides encounters some friction from the hole and this makes it move slower, causing it to start swirling backwards in a special shape called a torus.
RGB: {PPT SLIDE 4: Torus}.

Q-A - Camera 6: "On Pool"

Vinokur: For my last demo on motion I want to show you an amazing material that you can make at home. It's called a non-Newtonian fluid and it's made only from household corn starch and water. I actually have a big tank of this stuff which required 200 pounds of corn starch. This material is a liquid, but when you apply a force to it though motion, it becomes more like a solid.

Camera 6: "On Pool"

Vinokur: If I were to apply a force onto the surface of the liquid through motion, such as... Dancing, then I might be able to "Dance on water!" As long as I move my feet fast enough I should stay afloat and dance on the non-Newtonian liquid. ***{(Que Music) Dance. Sink into fluid at end of dance routine.}***
Demo: {Non-Newtonian Liquid}

Audio: Dance Music
Audio: Ta-Da Proud

Vinokur: I hope you enjoyed learning about the physics of motion and how it relates to the arts. Hey Professor Sprott, do you like to dance too? ***{Exit: Wheeling off after he sinks into the corn starch}***

Q-B **– Lectern Computer 1 {2011WOP-Slides.ppt}: "Sprott Dance"**

Sprott: I do like to dance. I even had a dancing photo in the newspaper once

RGB: {PPT SLIDE 5: Dance Photo}.

When you dance you use your feet,
It's a great way to build up heat.
I think that's kind of neat.
Don't you agree, Mister Pete?

Peter: A poet, you're not, but I do know someone who has been looking into heat with regards to special effects. Let's have a warm welcome for George the Big Bang Boomer!

Q-A**– Camera T2V1: "On Kinetic Simulator"**

Q-A**– Camera 5: "On Stage of Bottle Bomb"**

******Audio: Big Bang Sound Track***

Heat (George Hrabovsky): *Theater*

[Wearing Lab Coat or MAST Shirt]

[Turns to Peter]
Big Bang Boomer? Seriously?

[Turns to audience]

Hello, everyone! You've all seen movies and TV shows that have spectacular effects of things exploding and burning. Since many people consider movies and TV to be a form of art, would you like to see me blow stuff up and light things on fire for you?! (BIG Grin here!) For those of you who don't enjoy loud noises or have heart conditions, now might be the time to leave the room or cover your ears!

{Peter sticks fingers in his ears}

[Walking over to the table with the dewar and the pop bottle] What is an explosion? An explosion is when something expands really fast. We often think that something has to be hot when it explodes. Of course, [indicating the Dewar] here is something really cold! Liquid Nitrogen! Now, I would have be some sort of nut to put some of this into a pop bottle and seal it up [Evil Grin to the Audience as I pour a small volume into the bottle, seal it up, fix it into the frame and then put the trash can over it.] We will hear from that a little bit later, it will be quite loud. I put about a cup of liquid Nitrogen into the pop bottle and it will expand to nearly 700 cups of gas; I doubt that the bottle will hold it all.

- **2L Bottle Bomb** [with garbage can]) - things that are cold can also explode

Before we get to more of the good stuff, I have to explain how this is going to work; this is educational after all... So I have rigged up this to demonstrate how heat works.

- **Kinetic Theory Simulator:** (ball bearings on speaker),

Here we have a bunch of ball bearings in a box, think of the bearings as atoms in a substance, say water. [Turns on the apparatus and gets then to vibrate a little]. As they are here we can think of it like the atoms in a solid, sort of like they are frozen. As we turn up the heat the atoms move around more freely, this is like melting something. As we turn up the heat even more, we have boiled the liquid into a gas. Here the energy of motion is the temperature. The more the atoms move the higher the temperature. And you can see how the volume expands as we increase the temperature.

Another way to get things to explode is to burn them really fast. What happens is we burn things so fast that the atoms start moving so fast that the gas expands rapidly. For this you need something that combusts, like Hydrogen. Of course, what can possibly go wrong with Hydrogen?

- **[Cue short video of the Hindenburg].**

Here we have a couple of balloons. I just happen to have a stick with a match on it; why I have a stick with a match on it is up to your imagination... This first balloon has Hydrogen, and when I light it it will explode, and you will be able to feel the expansion of gas as it passes through the room; that will be what we call a shock wave.

- **Exploding Balloon**

[At some point the N2 bomb goes off.] Wow! That was spectacular!

I have been studying and chasing tornadoes for nearly 35 years. I thought it would be interesting to combine that interest with my interest in heat. Would you like to see me make a tornado out of fire?

- **Tornado Video clip that I will provide**

We begin by applying fuel to this flammable material. Then we light it, don't try this at home! Notice how the flame wavers and gutters, this is because the oxygen to feed the fire is bumping into the expanding gas. [places screen around the burning element and spin it] This vortex works by spinning the flame outward and upward in an updraft, this allows fresh oxygen into the base, keeping the fire going. In a tornado we get rotation and we get an updraft column; this cylinder of mesh acts like a chimney to get a good updraft going, and to get the vortex going by spinning the air.

- **Fire Tornado**

Audio: Ta-Da

Audio: Ta-Da-proud

[Turns to Sprott]
Thank you Professor Sprott, for inviting me to give these demos, and [turning back to the audience] I hope you will be inspired to study both physics, and the arts.

- **Ruben's Tube**

{Sprott does the Ruben's Tube demo here as a transition of heat to sound.}

Sound (Don Brandl): *Music*

Entrance: Don enters, searching for the source of sound (Ruben's tube). He explains standing waves (?) and how big instruments can make low sounds while small instruments can make high sounds. Sound as wave --> show on Oscilloscope

- **Oscilloscope Waveforms** - different instruments, different voices, consonance, dissonance, crowd participation - Ah vs Eee to transition into dissonance
- **Beats, Tuning Forks** (interference) - The two waves are not quite the same, and we hear these two waves interfering together in the beating.
- **Breaking a Beaker With Sound** -Like in these tuning forks, we have a certain frequency, or note, that an object can make. The same thing happens with other objects, like a string in a guitar or in... a wine glass! as a matter of fact, if we happen to play that sound INTO the object, we can get it to vibrate. Let's try it out with this wine glass... [Safety Glasses] Break glass. Explain it resonated so much that it broke - it couldn't take how far we were trying to make it bend!
- **How you make sound** (membranes, tubes, etc.) - get audience to name some ways we can make some sounds. Will bring out instruments used for exit. Will construct, with Ella's help, the Improv-o-tube

Audio: Ta-Da

Audio: Ta-Da-proud

EXIT: Don finishes up by talking about various ways that you can make sound. He demonstrates by getting various people to play instruments They all leave, having all they need to make a band. -> Ella's Improv brass, Reid with Banjo, Don with drum

- **Audible Frequencies**

Sprott: There are a lot of ways to make music These days we often use electronic instruments. You'v probably all seen music synthesizers. I have here an audio oscillator...

- **Theremin**

I also have here a very unusual electronic instrument called a "theremin." It was invented in 1920 by a Russian physicist and musician, Leon Theremin {SLIDE}. It was originally intended for military use as a proximity detector. It consists of two high-frequency oscillators, much too high for your ears to hear, one fixed in frequency and the other whose frequency I can control by varying the capacitance with my hand (demonstrates). What you are hearing is the beat frequency between the two oscillators. Unfortunately, I'm not very good at playing it, but here's what it sounds like when played by its inventor {VIDEO CLIP}. This illustrates one use of electricity in the arts.

- **Chaotic Circuit**

Sprott: Here's another electric circuit {SLIDE} that makes a sound. I'm proud of it because I invented it myself just last year...

To show you some other examples of how electricity is used in the arts, I'd like to introduce my

esteemed colleague, Professor Michael Winokur...

Electricity (Michael Winokur): *Movies*

Thank you Professor Sprott for that kind introduction

Well I've just come from the electricity laboratory and, if the sound of physics isn't scary enough, then perhaps you would like to watch a horror show (hopefully not this one).

17 second CLIP from Young Frankenstein

From early times electricity has been used to shock and frighten audiences. You may not know it but Thomas Edison, inventor of the electric light bulb, was involved with the movies (Powerpoint from 1910). His name even appears in the 1st Frankenstein movie back in 1910.

Electricity is nothing more than electrons in motion.

It still is amazing to me that one of nature's smallest things, the unseen electron, provides such dramatic displays of energy and power. A single electron's force is small, too small for you to feel. but there is strength in numbers. We **only** have to move them around a little.

In the back corner we have a device called "Jacob's Ladder". To make it work we need to push the electrons from one metal electrode to the other (scientist call this push **VOLTAGE or ELECTRIC POTENTIAL**). Quickly these electrons find a weak link in the air gap and jump back.

Demonstate:

- **Jacob's Ladder**

Flipping this switch starts the process. Once the electricity flows in the gap it heats the air and, as this air rises, the electric arc moves up. The pretty colors come from the air molecules that are excited by the electric current.

You can do a similar experiment at home with a nine volt battery and your tongue....ask you parents....it may be a tad unpleasant.

But I suppose you want to see a bigger example of pushing electrons around.

Is that so?

(Listen for audience).

We also have the ability to create lighting in our laboratory; just like in nature.

During a thunderstorm air currents between the Earth and the clouds move enormous quantities of electrons. They too find the weak link and jump. We see lightning. This slo-motion video captures nature in the act.

(5 second Video of lightning in slo motion).

With this device, a Tesla coil, we will push our electrons even harder. There paddles on this motor which transfer electrons to the coil and collect at this tip. They will escape to the metal ball and generate lightning ….

Shall we try?

- **Tesla Coil**:

Audio: Ta-Da

You might smell something a bit odd; lightning also creates ozone.

But I've forgotten something....something that goes with lightning.

Can someone help me?

Yes, thunder....we need a CRACK of thunder!

The last demonstration uses a "CA-PAC-I-TOR"; which is nothing more that two metal plates held close together. With this button switch we will move about one thousand million million electrons from one metal plate to the other. Then as this meter will show, at 5000 V, they will return by way of this thin piece of aluminum foil.

If all goes according to plan it will be really loud, just like a thunder clap.

Let's see...

- **Exploding Foil**

Audio: Ta-Da-proud

Well I thank you for letting me show you some things about electricity.

Electricity may even seem like magic... but there are others accomplished physicists that know something about that....

Magnetism (Ella Braden): *Magic*

{When the noise has died down, Ella walks on stage carrying a magnet and explains that her magnet was acting up backstage due to the changing currents from the Tesla Coil. Banter needs to be added to help Michael's exit.}

Ella: You know, I came here to tell you all about how physics is a part of performance art, especially magic. There are several demonstrations up here that demonstrate principles of magnetism, but look like magic.

- **Magnetic Field Lines**
- **Levitated Ball**
- **Eddy Currents: Guillotine**
- **Superconductors**

Audio: Ta-Da

Audio: Ta-Da-proud

Sprott: That does remind me of magic! You've all seen a magician levitate a lady haven't you? I wonder why they always use a lady?

Actually, I'm a bit of a magician myself. Just the other day I went to the hardware store and asked for a 3-foot long piece of rope, and they said "we don't have a 3-foot piece of rope, but we do have these 2 little short pieces." And I said, "heck, that's no problem because I'm a magician, and any magician can change 2 short pieces into one long piece..." ***{Applause}***

Now I really just made that up, but I did go to the hardware store and asked for a piece of rope, and they said "do you want the kind of rope that has 2 ends on one end and 2 ends on the other end? Or maybe you want the kind of rope that has 2 ends on one end and one end on the other end?" And I said "no, no, I just want the regular kind of rope---the kind where you tie a knot in the middle, you have a rope with 3 knots in it..." ***{Applause}***

Ella: You know Prof. Sprott, there's one more demonstration up here that looks a lot like magic, and I'd like to bring out another one of the physicists from the Department to help with it. Everyone please welcome Marty Lichtman!

- **Talking Head** ***{Marty as assistant to the talking head - Talking head is from the crowd}***

Ella: The trick is an optical illusion. If I walk in front, you can see my feet, because there's a mirror there. Now, I didn't grow an extra pair of legs, and neither did the table. The leg you see in back is actually a reflection of the leg in front.

Light (Marty Lichtman): *Art*

Marty: As Ella said, my name is Marty Lichtman, which is Hungarian for Marty "Man of Light", so that's what I'm here to talk to you about! We started off the evening with some stories, but today most of us get our stories through movies and television. And of course, those art-forms wouldn't exist without LIGHT! There are two features of light that make movies and television work, color mixing, and persistence of vision. Movies are shown to you at 24 individual frames per second. But when we watch them, we see continuous motion. To demonstrate this I have here a:

- **Laser Oscilloscope**

{Lights off, no spotlight}

The laser produces a single dot, and bounces off two mirrors. By moving the mirrors, I can move the dot, and if I turn on these motors, I can move the dot very fast. It moves so fast that when the light stimulates the photoreceptors in your eye, they stay stimulated long enough that you see a continuous line. That's persistence of vision.

{Lights on}

{Kenny jumps out.}

Kenny: I've been following you!

Marty: Oh no! It's my evil nemesis, my shadow! I can't seem to ever get rid of you!

Kenny: That's because you are limited by the speed of light! Whereas I, the shadow, can travel as fast as I like!

Marty: Light travels extremely fast. This chopped off rulers shows the distance light could travel in only 1 billionth of a second. That's 30 cm. So shadow, it about 30 meters from here to the back of the auditorium and back and a beam of light can travel that distance in only 100 nanoseconds, or 1 ten millionth of a second.

Kenny: 30 meters in 100 nanoseconds is 300 million meters per second, or 186 thousand miles per second. But I, shadow, am even faster. Watch how fast I can run up to the back of the room and return. TADA!

Marty: Pretty good, but you can't seem to convey information very fast! (HAHA.) Well, when you surprised me I was talking about persistence of vision, and there's something else I'd like to show you, that requires me to be VERY fast. When we go to the movies, we need a screen to project the image on. We can't see light unless it shines on something. Like the laser beam I used before, you couldn't see it until it shone on the screen, or the fog. But in the future, maybe movie theaters won't need screens.

Kenny: Impossible!

Marty: Not at all! It just requires me to wave this stick VERY fast. Watch this!

{Lights off, no spotlight}

- **Tubeless TV**

Kenny: It's Einstein!

Marty: The light is only reflecting back one line at a time, but if I move the rod fast enough, your photoreceptors can't respond fast enough, and you see an entire image!

Now, movies and TV would be pretty boring without color. And while we've got the lights

off, I'd like to show you how we produce those colors. If I take a white light and shine it through a prism, it diffracts into all the colors of the rainbow.

Audio: Somewhere over the Rainbow

Marty: The white light contains every part of the visible spectrum. But your television can actually only produce three colors, red, green and blue. So how can it show you all those beautiful colors? Well, when I mix green and blue, it makes teal. When I mix green and red, it makes yellow, and when I mix red and blue, it makes magenta. And when I mix all three, it makes white!

- **Light Mixing**

  This works because you actually only have three types of color receptors in your eyes, ones that are sensitive to red, ones sensitive to green, and one sensitive to blue. True white light stimulates all three of those color receptors, because it contains red green and blue, in addition to orange, yellow, indigo, violet, and every other color, but I can also trick your eyes by stimulating your three color receptors with only red, green and blue, causing you to perceive white light!

Kenny: But watch what happens when I cast, a SHADOW!

Marty: There are three ducks! And each one is a different color!

Kenny: That's because when I block each projector, it subtracts away from the white white light.

{Lights on}

Marty: Well that reminds me Shadow, that's how light mixes, but paint colors mix a bit differently, and I think that's right up your alley.

- **Paint Mixing**

Kenny: That's right, light colors add, but paint colors subtract. When I mix yellow and blue it makes green. On the screen red and green made yellow, but now when I mix red and green, I get well ….. brown?

Marty: Mmmm, delicious! Well Prof. Sprott, now that you know all about paint mixing, you should make a great artist! We'll leave you to it. Good luck with your painting!

{Marty and Kenny exit}

Audio: Me and my Shadow

Audio: Ta-Da-proud

Conclusion:

Peter: Professor Sprott, I notice you have been painting something. Can we see what you've done?

Sprott: I've been doing something that demonstrates both art and physics. Would you like to see it?

{Sprott turns the easel toward the audience revealing an apparently blank canvas}

Peter: It looks like you didn't even start yet.

Sprott: Ahhh, but that's where the physics comes in.

{Sprott turns on the UV light revealing a vivid sunset, and then turns it off. He explains fluorescent paints, shows some fractal artwork, and plugs his poetry/art book}

Sprott: To conclude the show, we have a special treat. Twenty-one years ago this month, while doing one of these shows, I noticed in the audience Professor Jim Latimer from the School of Music {SLIDE}. I recognized him as the conductor of the Capitol City Band. When he came down after the show, I jokingly said "you should write some theme music for The Wonders of Physics." He did, and he premiered it in our show in 1992. We've been using it ever since. [Jim is with us again today. Jim, please stand up.] He told me he's always been interested in science and that he's a ham radio operator, which is how I got started in physics.

In honor of the Year of the Arts, Jim, in collaboration with Frank Ferriano, has arranged a new version of The Wonders of Physics that was premiered by the Madison Marimba Quartet this past Christmas {SLIDE}. It runs about three minutes, and we we'll play it at the end of the show for those who want to stay and listen.

Sometimes science is portrayed as being in competition with the arts. But I hope we have convinced you that the two are very closely related. All of the arts rely on principles of physics, and scientists enjoy and profit from the arts just as much as anyone else. Thus I encourage you to learn all you can about science, but also to develop your talents in the arts, and even if you are like me, and have limited artistic skills, you can still appreciate and enjoy the talents of others.

And now I'd like to end the show in the same way we have ended every one of the shows for the past 28 years, by making for you a cloud...

{Sprott goes out with the usual liquid nitrogen cloud and the new theme music video.}

Audio: WOP-NEW-Theme (all 3 minutes of it)
T2G1 – WOP PPT – Left & Right

{Cast members come on stage through the side door and bow in unison.}

Audio: Science Songs

Miscellaneous Notes:

Old Power Point Slide Shows:

- ***2011wop-slides.ppt***
- ***ShowPromos08.ppt***
- ***wop09_powerpoint.ppt***