The Wonders of Physics 2017

Table of Contents

Characters:

Cast	Characters :)
Captain Clint Sprott	Clint Sprott
Cyrano Jones (tribble trader)	Peter Weix
Mr. Randall (Scotty, Chief Engineer)	Mike Randall
Lt. Norval (Sulu, helmsman)	Ryan Norval
Mr. Kra'Nee ()	Terry Craney
Lt. Seltzman (Vulcan science officer)	Andrew Seltzman
Communications Officer Ehlerding	Emily Ehlerding
Yeoman Keenan	Tara Keenan
Lt. Zhulu (Transporter operator)	Dani Zhu

Potential characters to choose from (as-is, or modify the character to suit you):

- Captain James T. Kirk, commanding officer of the USS Enterprise.
- Commander Spock, the ship's half-human/half-Vulcan science officer and first/executive officer (i.e. second-in-command).
- Lieutenant Commander Dr. Leonard "Bones" McCoy, the Enterprise's chief medical officer.
- Lieutenant Commander Montgomery "Scotty" Scott, chief engineer and second officer (i.e. third-in-command)
- Lieutenant Nyota Uhura, communications officer
- Lieutenant Hikaru Sulu, helmsman
- Ensign Pavel Chekov, a navigator introduced in the show's second season
- Nurse Christine Chapel.
- Janice Rand, the captain's yeoman.
- Sarek, Spock's father.
- Kang, Koloth, and Kor, three Klingons.
- Khan Noonien Singh (bad guy played by Ricardo Montalbán)
- Harcourt Fenton (Harry) Mudd, scoundrel and troublemaker
- Romulans
- Cyrano Jones, tribble trader
- Gorn (lizard man)
- Admirals

Resources

- 2015 PowerPoint Slide Show (This link is broken; please replace it with the 2016 Slide Show)
- Physics Lecture Demonstrations
    - An old Physics 103 Demo List
    - An old Physics 104 Demo List
    - WoP Demos from Previous Years
    - 85 Video Clips from Physics Demonstrations Book
- WOP sound library (see also Star Trek sounds)
- 2016 WOP script
- 2015 WOP script
- 2014 WOP script
- 2013 WOP script
- 2012 WOP script
- 2011 WOP script

Celebration of 50th anniversary of Star Trek. Slide show before show starts, trivia questions.

Demo List

- Motion (Mike R.)
  - Tesla Coil Console (for transporter)
  - BasketBall & Medicine Ball **- Working & Setup**
  - Ping Pong Ball Bazooka
  - Alcohol rocket **- Working & Setup**
  - Rotating platform
- Heat (Terry Craney)
  - Helium vs Hydrogen Balloon
  - Convection Candle ~~and or~~ ~~***Convection Tube***~~
  - Light the Match = “Reflectors”
  - Carbon Dioxide Trough
- Sound (Clint Sprott)
  - Gravitational Lens
  - Doppler Effect
- Electricity (Andrew Seltzman)
  - Jacob’s Ladder
  - Van de Graaff Generator
    - Hair
    - Pop Bottle Motor
    - Pinwheel
  - Plasma within Microwave
  - Plasma Cutter
  - Plasma Thruster
- Magnetism (Ryan Norval)
  - Ferrofluid
  - Jumping Ring
  - CRT with Magnet
  - Induction Heating
  - Superconductor [MagLev]
- Light (Emily Ehlerding)
  - Twinkling Star
  - Laser Balloon Popping
  - Geiger Counter and Sources
  - Mousetrap Chain Reaction

The Wonders of Physics 2017

- *34th Annual Presentation*

“Physics of Space Travel”

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

Lights: Main Lights only
Audio: Science Songs
(ON A&C) - Cameras 5 & 6: {Crowd Shots on A & C }
Intro ppt: https://uwmadison.box.com/s/jv6ibsre6wcym09ie0xstgwb3ubltgou
***(ON B) -** RGB {T1 Computer 1}: Optional PPT intro*
Lights: Change to Stage & Floods

Peter: Welcome to the (288, 289, 290, 291, 292, 293, 294, 295, 296, 297) presentation of *The Wonders of Physics*... Before the show begins, I would like to assure you that we make all our demonstrations as safe as possible provided you remain in your seats. **(*Last day only:* You will also notice that we are videorecording the show. If you don’t want to appear on the video or want your children to appear, don’t volunteer for any of the demonstrations.)**

Audio: StarTrek Intro2

Peter: Stardate 02.11.2017 Captain Sprott heard about the planet orbiting in the temperate zone around Proxima Centauri, the nearest star to our Solar System, and he has this crazy idea to mount an expedition to visit it and to seek out new life and new civilisations; to boldly go where no one has gone before. And so here for the 34th year, that indefatigable schemer, that intrepid space explorer, that wonder of physics, Professor Cliiiiiiiiint Sprott!

Audio: WOP Theme
(ON B) - {Lectern Computer 1 - PPT Slide #2}: **1960’s Enterprise & Bridge**

{ The curtain parts, and Sprott is sitting on the bridge of the Starship Enterprise wearing a Star Trek costume. }
{ He rises from his chair and approaches the audience. }

Sprott: Welcome to ***The Wonders of Physics*!** When I was a student, one of the things that inspired me to study physics was when John Kennedy said “We choose to go to the Moon in this decade and do the other things, not because they are easy, but because they are hard…” That was over 50 years ago. I think we need a new challenge, and going to Mars is too easy. We need to go all the way to that new planet just discovered around our nearest star.

Motion (Mike Randall)

Peter: But Professor Sprott, we don't have rockets powerful enough to take us there!

Sprott: Nonsense! I already have our Chief Engineer Mike Randall investigating the physics of making really big rockets. Lt. Zhulu, beam him in…

Dani: Aye, Captain

{ Dani Z. stands and immediately flips a switch on the Tesla Coil console to turn on the laser dots (there's a 5 second delay). At the same time, Bill Z. turns off the room lights (about a 3 second delay to total darkness). When the room is completely dark, Mike R. quickly steps through the curtains and stands still. He is wearing a Starfleet red shirt, plaid kilt and tam o' shanter hat. }

Lights: Stage & Floods -- OFF

Audio: MainTransporter2.wav

{ About one second after MainTransporter2.wav starts playing, Dani Z. flips the switch to turn off the laser dots (5 second delay), and Bill Z. fades the room lights back on. Mike R. walks from the transporter to bagpipe music. }

Lights: Stage & Floods -- ON

Audio: bagpipe MP3

Mike R: (in a heavy Scottish accent): Aye, Cap'n! Call me Scotty! Ya canna change the laws o' physics! Lang may yer lum reek! You're a wee scunner! Ma hovercraft's full o' eels!

Sprott: Scotty? Mr. Randall, I didn't know you were Scottish.

Mike R: (no accent): Um, actually...I'm not. I'm wearing this because I lost a bet with my wife.

ON B) - {Lectern Computer 1 - PPT Slide #2}: Newton's 3 Laws

Mike R: Alright, let's talk about what it will take to get to Proxima Centauri. Space travel is governed by Newton's three laws of motion. Newton's first law says that an object at rest stays at rest, and an object in motion stays in motion. Put another way, Newton's first law says that stuff - or matter, as scientists like to call it - wants to keep doing what it's already doing. If something is sitting still...it wants to keep sitting still! If something is moving, it wants to keep moving in a perfectly straight line, at exactly the same speed, FOREVER! Or until some outside force pushes or pulls on it.

Mike R: Newton's first law is good news for space travel! That's because space is...mostly...space! There's not much out there for our spaceship to run into to slow it down. So once we get our spaceship up to speed, it will keep going on it's own!

Mike R: I'll need a cadet from the audience to demonstrate Newton's second law. ***{ Selects child from the audience }***. Hi! What's your name? ***{ Get's name, and hands child the basketball }***.

Demo: { Basketball and Medicine Ball }
~~(on A&C) - Camera 5 or 6: { Basketball } ??~~

Mike R: OK ***<name>***, throw this basketball to me. ***{ Child throws ball }***. That was a great throw! OK ***<child>***, when you threw that ball, what did you do TO the ball? ***{ Coach child to say they pushed the ball }***. Yeah, you pushed it! Scientists have a word for that. They call a push or a pull a FORCE. You applied a force to that ball. The ball is made out of stuff. What do scientists call stuff? MATTER! The AMOUNT of matter in the ball is called its MASS. So, you applied a FORCE to a MASS. With me so far? Now, when you did that, the ball - which hadn't been moving - suddenly did what? ***{ Coach child to say that it moved }***. It MOVED! Specifically, you made it speed up. Scientists call a change in speed or direction ***{ audience participation }***. Long word, starts with "A"... Acceleration! When you pushed on the ball, you made it accelerate! Newton's second law puts all three together: force, mass and acceleration. Some of you may even know the math equation Force equals mass times acceleration **(slide *F = ma*)**. But the main thing is to remember is that force, mass and acceleration all go together. ***<child>*** stay right here. We're going to do this again, but with a different ball. ***{ Take basketball away, and bring in medicine ball }***. OK ***<child>***, throw me the ball! Now, when you pushed on the ball, did you push the same as before? Did you push more? Or did you push less? Yes! You pushed MORE. You knew that, with more MASS, you had to apply a bigger FORCE to get the ball accelerating fast enough to make it to me! Everyone! Let's give ***<child>*** a big hand!

Audio: Ta-Da-1 {Child returns to their seat.}

ON B) - {Lectern Computer 1 - PPT Slide #4}: Newton's 3 Laws

Mike R: How does Newton's second law apply to space travel? We have a long way to go to reach Proxima Centauri. So we want our spaceship to accelerate to the highest speed possible, right? Newton's second law says we can do this by applying a really big force, AND by making our spaceship as light as possible! Reducing the mass!

Mike R: Last year, world-famous physicist Stephen Hawking, along with a group of scientists and investors, unveiled an ambitious new project called Breakthrough Starshot, which aims to build tiny, light-propelled robotic spacecraft that could visit another nearby star - like Proxima Centauri - after a journey of just 20 years. The mass of each "nanocraft" would be about the same as this ping pong ball.

Demo: { Ping pong ball cannon }
(on A & C) - Camera 5: { Ping pong ball cannon }

Mike R: I have an identical ping pong ball in this tube. I'm now going to pump out most of the air. When I pop the tape on this end, the air rushing back in will push on the ping pong ball with over 25 POUNDS of force! Let's see what happens! Cover your ears! 5 - 4 - 3 - 2 - 1 (LOUD BANG).

Audio: Ta-Da-1

Mike R: Wow! That was fast! The ball experienced almost 2,000 g's of acceleration, with a final speed close to the speed of sound - about 760 miles per hour!

Mike R: Now, the nanocraft aren't going to be accelerated by AIR. Each nanocraft will unfurl a giant reflective sail - about the same size as this part of the wall (pointing). Super-powerful ground-based lasers will then bounce a light beam off the sail to accelerate the craft to 20 percent of the speed of light - about 134 MILLION miles per hour - within 10 MINUTES! When the nanocraft reaches its destination, it will radio pictures and sensor readings back to Earth. Radio waves travel at the speed of light, so it will take about 4 YEARS for the pictures to get to us!

Mike R: I've saved the most important Law for last. Newton's Third Law says that, for every action, there is an equal and opposite reaction. Or, put in simple terms, if you push against something, it pushes BACK! Newton's Third Law is often referred to as the Law of Rockets. In a rocket engine, a lot of gas goes this way (gesturing) and the rocket goes the other way.

Demo: { Turntable }

Demo: { Alcohol rocket } Demo Link

Mike R: I happen to have a rocket with me today! This rocket is fueled with a small amount of alcohol. Ready for blast-off? 5 - 4 - 3 - 2 - 1. (Light rocket)

Audio: Ta-Da-1

Mike R: How about that? The burning gases went this way, and the rocket went the other. Now you've got the basic science you need for space travel.

Audio: Red Alert.wav

Mike R: Oh no! The tribbles are in the replicators again! Hey, I can beam them over to Mr. Weix's house...where they'll be no tribble at all!

{ Mike R. exist through Stage Right door. }

Audio: Door3.wav

Heat (Terry Craney)

Peter: There are many types of plasmas that we know of. One of the hottest is our closest star. Can anyone tell me what our closest star is? Our Sun, that's correct. Captain Sprott if we get too far from our Sun, how do we stay warm?

Sprott: Heat is the easiest form of energy to generate; there are lots of ways to do that. Dr. I Kra Nee will explain. Lt. Zhulu, beam him in…

Dani: Aye, Captain

{ I Kra Nee is beamed in by transporter. Dani Z. stands and immediately flips a switch on the Tesla Coil console to turn on the laser dots (there's a 5 second delay).
At the same time, Bill Z. turns off the room lights (about a 3 second delay to total darkness). When the room is completely dark, Terry C. quickly steps through the curtains and stands still. }

Lights: Stage & Floods -- OFF
Audio: MainTransporter2.wav

{ About one second after MainTransporter2.wav starts playing, Dani Z. flips the switch to turn off the laser dots (5 second delay), and Bill Z. fades the room lights back on. Terry C. walks from the transporter. }

Lights: Stage & Floods -- ON
{ Clint turns on the IR heater ASAP, Takes about 4 minutes to heat up }

I Kra Nee: Thank you Captain Sprott. So yes, let's look at some principles of heat and heat transfer. Let's start by producing heat by means of electricity. We have here an electrical coil that creates heat. In this case the heat is a type of radiation called infrared. We can use electricity to produce infrared radiation to heat the inside of our spacecraft and to keep our astronauts warm. In fact, infrared radiation will be the main way we will heat our spacecraft.

I Kra Nee: Just like regular light, infrared radiation can be focused by a mirror. (And by the way, do you know what happens when light turns bad? It has to go to a prism.) The heated coil is at the focal point of this parabolic mirror. The infrared heat is sent across the room to the other mirror. At the focal point of that mirror is a match. If we get lucky, let's see what happens- now this may take a minute or so. Yell out if you see something happen! **{Camera on match}** Yes, the match lit up! The infrared radiation created enough heat to light the match.

Demo: Light the Match *Demo Link* *{ Infrared Radiation/Mirror }*

(ON A&C) - Cameras 4 & 5:

Audio: Ta-Da-1

I Kra Nee: Another way of transferring heat is though the movement of air. Here we have an ordinary candle. Have you ever wondered why the flame rises? The flame heats the air above it and makes the air less dense, thereby causing it to rise. Cold, denser air from the bottom and sides comes into the flame and fuels it with fresh oxygen. Unfortunately, this will **not** happen in our spacecraft because there is no gravity and therefore no density difference, but more on that in moment.

Demo: Convection Candle *{Link to Convection Tube - Another cool demo}*

(ON A&C) - Cameras 6:

I Kra Nee: Now if we put a cylinder over the flame and seal the bottom, what happens? **{camera on flame}** Right, it goes out! Fresh air, simply, can not get to the flame.

I Kra Nee: Now, one of the main ideas in science is that experiments are repeatable. But let's this time place a piece of metal in the cylinder- change it a bit. What happens? Right, the candle flickers a bit but stays lit! The hot air goes up one side of the cylinder, while cold fresh air comes down the other side allowing oxygen to fuel the flame. **{Show smoke wand}** This process is called convection or setting up a convection current. As I said earlier, convection will not take place inside our spacecraft since there is no gravity. So how will the equipment and even the astronauts be heated and cooled inside our craft? By creating artificial air flow by using fans and blowers. The inside of the spacecraft is going to be a bit noisy.

I Kra Nee: Finally, how is the air flow direction decided? Simply by chance -- however it starts it keeps going that direction. So finally to show that there is no trickery here, let's pull the metal out.

Audio: Ta-Da-1 **{ When the candle goes out }**

I Kra Nee: **So what happens!!** The flame goes out again. The experiment is repeatable. In the weightlessness of outer space, there is no convection, and the candle would not burn.

I Kra Nee: So now let's look at another way gases move. Anyone have a birthday today? This week? Come on down birthday boy/girl. How old are you?

(ON A&C) - Cameras 6:

Demo: Carbon Dioxide Trough

Audio: Happy Birthday

I Kra Nee: I am going to light four candles in honor of your birthday. Why? Because I want to show you something quite unusual. ***{birthday guest does this part}*** In just a moment, I want you to take this beaker and pour it down the trough. What's in it? Water? Air? OK, pour. What happens? Right, the candles go out.

Audio: Ta-Da-1 **{ When the candle goes out }**
{Thank the birthday person}

I Kra Nee: Why? The beaker did not have air but instead a gas called carbon dioxide. CO_2 is 50% heavier than air so it will stay in the beaker, and you can pour it like water. It falls just like the cold air in the candle and cylinder demo. But again in the weightlessness of space, the CO_2 created by our breathing, as we exhale, stays next to our mouths and will not convect or fall. It would stay next to our mouths and we would risk suffocation as we sleep. Another reason to have blowers and fans onboard our spaceship and thank goodness for convection currents here on earth.

(ON A&C) - Cameras 6

Demo: { Dry Ice}

I Kra Nee: By the way, where did this CO_2 come from? From a solid called dry ice **(demo: dry ice)**. Why is it called dry ice? It's not wet, but very cold- about -109 F or -78 C. Dry ice is also unique in that it changes directly from a solid into a gas with no liquid stage- hence "dry" ice. This process is called sublimation. Are there other materials that sublimate? Does regular water ice sublimate? Well interestly enough, yes it does. Snow will sublimate away during the winter even if the temperature stays below freezing and will slowly lower the snow level. Ice cubes in the old type ice cube trays will sublimate and become smaller if they are not used for several months in the freezer.

Audio: Ta-Da-1

I Kra Nee: Here we have a balloon that is lighter than air so it rises. What do think is in it? Helium? Are there other lighter than air gases? Maybe hydrogen? So how can we tell which it is?

<u>I Kra Nee:</u> That's right, explode it with a match. I will put a match on the end of this stick and bring up to the balloon. Let's see if it explodes or just burns through the balloon-- ***(small burst as the balloon pops)-*** it had ***helium***.

Demo: { Helium Balloon Pop }

<u>I Kra Nee:</u> Now over here is another balloon. Let's try the match again.
{ Warn audience that they should cover their ears }

Demo: { Exploding Hydrogen Balloon }

Audio: <u>Ta-Da-1</u>

<u>I Kra Nee:</u> ***WOW!!*** That must have been ***hydrogen***, a very flammable gas. Hydrogen is a good initial rocket fuel because it's very light and contains a lot of energy. It will be used in our rockets to lift our spacecraft outside the earth's gravity. So as you can see, we can heat our spacecraft with infrared radiation created by electricity and use hydrogen in our rockets; there is nothing to worry about Mr. Weix.

{ Exit through Stage Right door. }

Audio: Door3.wav

Sound (Clint Sprott)

Peter: OK, but how are you so sure there really is a planet there to visit?
{ Sprott rises from his seat on the bridge and approaches the audience. }

Sprott: I'm glad you asked.There are four ways to detect exoplanets:

ON B) - {Lectern Computer 1 - PPT Slide #6}: planetary 1

Sprott: First, you could try to view them directly (slide 1), but current telescopes aren't powerful enough to make that practical unless the planet is very large and the star is very dim and nearby.

ON B) - {Lectern Computer 1 - PPT Slide #8}: planetary 2

Sprott: Second, you can use gravitational lensing, an effect predicted by Einstein's (slide 2) General Theory of Relativity. If a second star happens to pass in front of the one being observed, its light is greatly magnified, just like with a regular lens (slide 3). A sufficiently massive planet in orbit around the star can produce additional lensing, and several very distant planets have been found this way.

***(ON A&C) -* Cameras 5 or 6:**
Demo: { Gravitational Lens } ***Demo Link***
Audio: Ta-Da-1

ON B) - {Lectern Computer 1 - PPT Slide #10}: planetary 3

Sprott: Third, you can observe the small decrease in light from a star as a planet passes in front of it (slide 4). This is an effective method using telescopes in space, and hundreds of exoplanets have been detected this way, but it requires that the planet be close to the star and orbiting in just the right plane.
ON B) - {Lectern Computer 1 - PPT Slide #12}: planetary 4

Sprott: The oldest method, and the one used to detect the planet orbiting Proxima Centauri makes use of the Doppler effect (slide 5) ...
Demo: { Doppler Effect Ball } ***Demo Link***
ON B) - {Lectern Computer 1 - PPT Slide #14}: Doppler Effect
Audio: Ta-Da-1

Sprott: And so, Mr. Weix, I think we can quite confident that there really is a planet there to visit.

Electricity and Plasma (Andrew Seltzman)

Peter: OK, maybe you're right, but how do you propose we build a propulsion system for such a long journey?

Sprott: We can use electric propulsion, Lt Seltzman will explain. Lt. Zhulu, beam him in…

Dani: Aye, Captain

{Andrew S. is beamed in by transporter. Dani Z. stands and immediately flips a switch on the Tesla Coil console to turn on the laser dots (there's a 5 second delay).
At the same time, Bill Z. turns off the room lights (about a 3 second delay to total darkness). When the room is completely dark, Andrew S. quickly steps through the curtains and stands still. }

Lights: Stage & Floods -- OFF
Audio: MainTransporter2.wav

{ About one second after MainTransporter2.wav starts playing, Dani Z. flips the switch to turn off the laser dots (5 second delay), and Bill Z. fades the room lights back on. Andrew S. walks from the transporter. }

Lights: Stage & Floods -- ON

Seltzman: Gas, captain. While under impulse power the ship expends fuel, we call it plasma, but it is simply ionized gas.

Peter: Well I don't see any plasma around, how do we make a plasma?

Seltzman: A plasma is a state of matter, much like a solid, liquid, or gas, but in an excited state

ON B) - {Lectern Computer 1 - PPT Slide #16}: Van de Graaff Generator
https://upload.wikimedia.org/wikipedia/commons/thumb/c/c2/Van_de_graaf_generator.svg/1920px-Van_de_graaf_generator.svg.png

Seltzman: The van de Graaff generator is putting charge on your body. Like charges repel, and thus the strands of your hair repel, causing them to stand up.

Demo: { Van de Graaff Generator - Hair } Demo Link

Audio: Ta-Da-1
(ON A&C) - **Cameras 6:**

Demo: { Van de Graaff Generator - Pop Bottle Motor } ***[electrostatic motor]***
ON B) - {Lectern Computer 1 - PPT Slide #16}: electrostatic motor
http://amasci.com/emotor/emotr2.gif

Audio: Ta-Da-1

Seltzman: We can use this effect to propel a spacecraft by using electric repulsion to accelerate the gas out the back of our spacecraft, thus creating thrust.

(ON A&C) - **Cameras 3:**
Demo: { Van de Graaff Generator - Pinwheel} ***Demo Link*** ***[ion propulsion]***

Seltzman: One of the easiest ways to turn a gas into a plasma is with electricity.

(ON A&C) - **Cameras 4 or 5:**
Demo: { Jacob's Ladder }
?? Audio: Ta-Da-1

Seltzman: Once the gas is turned into a plasma we can use it for propulsion by accelerating it out the back of our spacecraft with electricity. To demonstrate this I will need an assistant from the audience with long hair.

(ON A&C) - **Cameras 6:**
Demo: { Plasma within Microwave }

ON B) - {Lectern Computer 1 - PPT Slide #18}: Plasma Cutter
Slide
Demo: { Plasma Cutter }

Seltzman: We can use this effect to propel a spacecraft by using electric repulsion to accelerate the gas out the back of our spacecraft, thus creating thrust.
ON B) - {Lectern Computer 1 - PPT Slide #20}: Dawn.png

Lights: Stage & Floods -- OFF
Demo: { Plasma Thruster }
Lights: Stage & Floods -- ON

Seltzman: I'd like to tell you more about plasma propulsion, but my scientific expertise is needed on the bridge. Live long and prosper.

{ Exit through Stage Right door. }

Audio: Door3.wav

Audio: Red Alert.wav

Magnetism (Ryan Norval)

Audio: Red Alert.wav

Peter: Captain Sprott, ***I have a red alert***! There is an ion storm approaching!

Sprott: Relax Mr. Weix. Lt. Norval can help. Lt. Zhulu, beam him in…

Dani: Aye, Captain

> ***{Ryan N. is beamed in by transporter. Dani Z. stands and immediately flips a switch on the Tesla Coil console to turn on the laser dots (there's a 5 second delay).***
> ***At the same time, Bill Z. turns off the room lights (about a 3 second delay to total darkness). When the room is completely dark, Ryan N. quickly steps through the curtains and stands still. }***

Lights: ***Stage & Floods -- OFF***

Audio: MainTransporter2.wav

> ***{ About one second after MainTransporter2.wav starts playing, Dani Z. flips the switch to turn off the laser dots (5 second delay), and Bill Z. fades the room lights back on. Ryan N. walks from the transporter. }***

Lights: ***Stage & Floods -- ON***

Norval: Ion storm you say?! Ah, I've got it, we'll just raise our magnetic shields!.

Sprott: While you do that, could you explain to us about magnetic fields?

Norval: Alright, let's begin by examining the magnetic field more. One way to see magnetic fields, which are usually invisible, is with a ferrofluid.

Audience Question:

By the way, does anyone know which metals are typically magnetic?

- ***Ans:*** Iron, Nickel, or Cobalt

Audience Question:

Of those three metals, Iron, Nickel and Cobalt, can anyone guess which one the FERRO-fluid is made of?

- ***Ans:*** Iron

Demo: { Ferrofluid }

(on A&C) ***- Table 2 Video 1: { Ferrofluid }***

ON B) - ***{Lectern Computer 1 - PPT Slide #22}:*** Slide -1

Norval: We can see that when I bring the magnet close the the Ferrofluid, the iron in the liquid begins to move. You can see the hedgehog like structure that forms when the magnet is near the Ferrofluid. Each of the spikes is the iron attaching itself to a magnetic field line. If I keep the magnet still, nothing changes, I can even let it go and the magnet is stuck to the iron, but when I move the magnet again, the metal follows. It's these moving, or *changing* magnetic fields that allow us to do useful things with magnets.

Audio: Ta-Da-1

Norval: Now let's look at how we can use these magnetic fields to propel us in space. So, what we have here is a magnetic projectile, which operate the same way magnetic propulsion systems could. Let's see it in action.

Norval: The launcher here takes electricity and stores the energy. When I discharge it, it produces electric currents and magnetic fields. As the magnetic fields grow, they create currents in the ring. These current feel a magnetic force, and that force launches the ring upward! We can amplify that force in a variety of ways, two ways we can do it is to lower the resistivity of the aluminium to allow more current to flow, and reshape the magnetic field, so the ring feels that force longer. Let's start by changing the shape of the magnetic field.

Demo: {Jumping Ring } - [No LN2 & pipe]

Audio: Ta-Da-1

Norval: So we see that by reshaping the magnetic field with the iron pipe, we keep the ring in the magnetic field longer and it goes higher. Now I'll dip the ring in Liquid Nitrogen, which is really cold. Making metal cold make lowers its resistance, lower resistance allows more current to flow, and thus more magnetic force to be felt.

Norval: Ok that wasn't quite as impressive as just adding the pipe, but who wants to see what happens when we combine the effects?

Demo: {Jumping Ring } - [LN2 & pipe]
~~***Audio: Charge - [as you look towards the ceiling]***~~
Audio: Ta-Da-1

Norval: Now for as interesting as magnetic propulsion might be, magnetic fields might be even more useful as the starship shields, to protect from space weather and other thing hazards.

ON B) - {Lectern Computer 1 - PPT Slide #24}: Slide 2

Norval: One threat to astronauts on their way to Proxima centauri might be cosmic and solar radiation, or even worse that ion storm Mr. Weix is scared of. All these types of space weather are mostly made up of high energy, electrically charged particles, that might be harmful to the astronauts, or the ship! Because the particles have a charge magnetic fields can deflect these particles:

Demo: CRT with Magnet

(ON A&C) - Table 2 Video 2:

Norval: So, here we have an old CRT-tube, it projects an electron beam. Electrons are one type of charged particle. As I move the magnet near the beam it deflects. If I change the orientation of the magnet, I can change how I deflect the particles. We can design space ships to have magnetic shield so that we can fly through space weather with deflector, or redirector shields!

Audio: Ta-Da-1

(ON A&C) - **Cameras 6:**

Demo: Induction Heating

Norval: Even solid metal objects can be altered by a magnetic field. Over here we have a magnetic oscillator, it makes a magnetic field one way, then flips it upside down back and forth, it does this really fast. If an asteroid is on a collision course with our spacecraft, we could do the same with our magnetic shields. The metal only picks up a bit of the field, so we can use some wire loops to amplify the effect. The metal and the wire pick up the oscillating magnetic field, and a current is induced, the current then heats the metal, just like a phaser… err toaster would. If we had a big enough power supply on our ship, you could image vaporizing asteroids that come near our shield.

Audio: Ta-Da-1

Norval: Lastly, we could use magnets to help transportation aboard our starship. Superconductivity allows for magnetic levitation. So by itself the superconductor isn't very impressive at room temperature. However when it's cooled, it suddenly produces really strong magnetic fields, thanks to some quantum effects. I can lock it in place over these ordinary magnets. Once locked, the magnet will stay on the track, resisting side to side motion, and move freely along the track. We could use these magnetic tracks to move really quickly inside our space ship, or set up tracks to carry heavy cargo down to a colony once we arrive at proxima centauri.

Demo: Superconductor [MagLev]

(ON A&C) - **Cameras 5:**

Audio: Ta-Da-1

Norval: So you see Mr. Weix, there is no need to be afraid on any nasty space weather, magnetism will protect us!

Peter: Well magnets certainly do look like an attractive option....

{ Exit through Stage Right door. }

Audio: Door3

Light (Emily Ehlerding)

Peter: I'm still not convinced that would work.

Sprott: OK, then we can erect a large sail and use the pressure of light from the Sun or we could shine a powerful laser at it and push it along. Or we'll just go all the way and get a nuclear reactor. Lt. Ehlerding will explain. Lt. Zhulu, beam her in…

Dani: Aye, Captain

Lights: Stage & Floods -- OFF
Audio: MainTransporter2.wav
{ About one second after MainTransporter2.wav starts playing, Dani Z. flips the switch to turn off the laser dots (5 second delay), and Bill Z. fades the room lights back on. Emily walks from the transporter. }

Lights: Stage & Floods -- ON

Emily: It's true. In order to get ourselves to where we're going, *we're really going to have to "planet" out!*
Audio: Rimshot.wav

Emily: We have so many more power options we could use, all with different types of radiation. Now, when I say "radiation", I'm not talking about the heat we learned about earlier. I'm talking about electromagnetic radiation. *Slide 1: {EM spectrum}* Radiation is just a fancy word for light.

ON B) - {Lectern Computer 1 - PPT Slide #26}: Slide 1: {EM spectrum}

Emily: Visible light, the stuff we can see, makes up just this tiny part of what's known as the electromagnetic spectrum. And, come to think of it, the light we can see will also be really important out there in space… cuz it gets really dark out there. All we will have to guide us is the stars.

Emily: Have you ever noticed how stars seem to sparkle when you see them at night?

Demo: Twinkling Star
Audio: Twinkle little star

Emily: Turns out that light can travel through anything, even a vacuum like in space. See? *{spray smoke}* The beam of light is traveling through right here, we just can't see it.

Whenever you look up at the stars from Earth though, that light has had to pass through our atmosphere to reach your eye. Kind of like how, when I light this Bunsen burner and wave it in front of this laser, the laser light twinkles. You see? When the burner is in front of the laser, the spot twinkles and when I take it away, it goes back to being a boring dot.

ON B) - {Lectern Computer 1 - PPT Slide #28}: Slide 2: {Mars}

Emily: As a matter of fact, lasers like this one could also be really helpful in getting us off of Earth! Really powerful lasers have been proposed to be a way to launch ships out of Earth's atmosphere *Slide 2: {Mars}* NASA says we could get to Mars within three days if we could get this technology to work. We all know that lasers are powerful, and you definitely shouldn't shine them in your little brother's eye. Let me show you why…

Demo: { Laser Balloon Popping } {spray smoke into box to show the laser beam first}
***(ON A&C) -* Cameras 5:**

Emily: Now here I've got another laser, and an ordinary balloon. See? If I spray the smoke again we can see the laser beam. Now, if I put the balloon inside the box, where it will be in the path of the laser… (boom) Light really is powerful! Since the balloon is colored, it absorbs some of the energy from our laser here, which heats up a small part of the balloon and causes it to explode.
Audio: Ta-Da-1

Emily: So a launch from a powerful laser like that could help get us out of our Solar System. Which, by the way, do you know how the *Solar System holds up its pants? With an asteroid belt*.

Audio: OhDear!.wav

Emily: Now we've gotten away from Earth, but we will need power to keep our spaceship up and running. That's where we turn to my favorite technology…. Nuclear power!!

ON B) - {Lectern Computer 1 - PPT Slide #30}: Slide 3: { Radiation Symbol }

Emily: Nuclear power is basically capturing the energy from atoms as they split apart, or undergo fission. If we capture that energy, we can turn it into electricity, just like people do with burning coal or wind turbines.

Emily: Radioactive materials are atoms that are unstable and fall apart on their own. When they fall apart, they emit different types of radiation. I've got some radioactive sources here. Now, I've taken way too many classes on how to deal with these things safely, but in our ship we're going to want to protect ourselves from this radiation that's coming out of our reactor or even from outer space! So we need to shield ourselves.

(ON A&C) - Cameras 6:
Demo: { Geiger Counter and Sources}
{what materials to shield each type of radiation, use detector & paper, lead, etc; fiestaware?}

Emily: The particles given off by these different sources have different energies, which means they will need to be shielded differently. This is a Geiger counter, and it measures radioactivity. Clicks mean radioactivity. This alpha source gives off huge particles that can't really travel all that far. See? When I stick just a single sheet of paper in front of the source, we can't detect the radioactivity anymore. Now, this is a beta source, and those particles are a little smaller and can go a little farther then. A piece of paper doesn't do anything for us here. We need some good thick lead to protect us from these beta particles. Now this is a gamma source. It gives off super small particles called photons, which are crazy hard to shield. See? Even a huge piece of lead doesn't stop these. Actually, there are gamma rays coming from outer space all the time here on Earth. That's why this thing is going off even though I'm not holding it by a source. Nuclear reactors usually use huge atoms, like uranium-235 or plutonium-239. You just have to give it a neutron (which is a tiny particle usually found in the nucleus of an atom) to absorb, and it will break apart into two new atoms. When that atom splits, it gives off more neutrons that can be absorbed by other atoms, which split and give off even more neturons…. You get the picture. It's called a nuclear chain reaction, and once it starts, it's really hard to stop. Believe me. Does someone want to help me start our chain reaction here?

(ON A&C) - Cameras 6:
Demo: { Mousetrap Chain Reaction } ***Demo Link***
Audio: Ta-Da-1

Emily: So I think we have plenty of options to keep us powered out there in space. And now, *I've got to make like uranium-235 and split!*

Audio: Crickets.wav
{ Exit through Stage Right door. }
Audio: Door3

Closing (Sprott, Cast)

Peter: Well, maybe that would work, but Professor Sprott, how long will all this take?

{Sprott rises from his seat on the bridge and approaches the audience. }

Sprott: I was hoping it would be done by now, but Steve Narf was busy with other things.

{Steve steps out through the curtain and shrugs}

Sprott: But seriously, I think we know enough about the physics to make this possible, but it might take another hundred years to develop the technology. However, Proxima Centauri is very far away, and a one-way trip would take another 20 years even if we could travel at 20% the speed of light. But I'm quite sure that someday this will be done, and maybe one of you will be on that first voyage...

Sprott: Meanwhile, I'll get back to work constructing the starship that may eventually take us there, and I thank you all for coming...

(ON B) - *{Lectern Computer 1 - PPT Slide #32}:* **NG Enterprise & Bridge**

{Sprott takes a seat on the bridge of the Enterprise, flips a few switches, and disappears in a cloud of liquid nitrogen}

Demo: {LN2 Cloud}

(ON B) - *RGB {Lec Computer 1}: PPT SLIDE # 34/35 - Clouds / Thank You - Use slide of a rocket being launched*

(ON B) - *DVD Video: Theme music video*

Audio: WOP Theme-long-3m22s.wav

Theme music video plays.

{Cast enters from right and left doors and bows in unison. Sprott joins them for a second bow.}