

The Wonders of Physics 2022

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Characters:

Cast	Characters
Clint Sprott	Himself
Pete Weix / Akire Trestrail	Winter Olympics Chairman
Terry Craney Katie Harrison	Master of Motion Eminence of Energy
Haddie McLean	Wizard of Weather
Mike Randall	Director of Deafening
Michael Winokur	Chairman of Charges
Shimon Kolkowitz / Mallory Conlon	Quantathelete

Premise

The Physics Department presents a proposal to the Olympics Committee to host the 2034 Winter Olympics in Madison with some minor changes to the rules and some unusual physics events.

Demo List - UPDATE AS YOU GO:

Sprott (Opening)

- Lighted torch and methane-filled balloon suspended from above

Terry (Motion) “Master of Motion” and Katie Harrison “Eminence of Energy”

- [Ring, Disc, and Sphere, 1Q10.30](#)
- [Rotating platform and Dumbbells, 1Q40.10](#)
- Hammer Toss, 1D40.12
- [Earth-Moon System, 1D40.35](#)
- Meter Stick on Fingers, 1J10.20
- [Air Pucks, 1N40.25](#)
- Magdeburg Hemispheres, 2B30.30
- [Catch a Meter Stick, Reaction time, 1C30.55a](#)
- [Catch a Dollar, Reaction time, 1C30.55b](#)

Haddie (Heat)

- Adiabatic expansion—make clouds if snow is needed
- Ethanol rocket for speed skaters
- Bernoulli beachball volleyball
- IR Hide and Seek (use IR camera) 3 screens, one fine mesh, one plexiglass, one black plastic, IR camera on tripod to project on screen for audience viewing
- Turning copper medal, to silver medal, to gold

Mike R. (Sound) “Director of Deafening”

- Range of Hearing, 3C20.10
- Speed of pulses on ropes, 3B10.18
- Hydrogen / air balloon (+ hearing protection for presenter)
- Decibel meter (for H₂/air balloon explosion)

Michael W. (Electromagnetism) “Chairman of Charges”

- Bike hooked to generator to power light during blackout
- Faraday cage/Tesla coil, new penalty box for ice hockey
- Can launcher instead of guns for biathlon
- Eddy currents for safe landing/braking, magnetic & steel balls, copper and plastics tubes, liquid nitrogen?

- Theremin for Olympic theme??
- Ion propulsion with static electricity, Van de Graff

Shimon / Mallory (Quantum Connoisseurs)

- Superconducting track (racing)
- Guiding laser/total internal refraction (racing)
- Photoluminescent sheets - basically make the electron transition demo giant
- [Switch pitch ball](#) to showcase superposition and entanglement(dodgeball)

Sprott (Closing)

- Liquid Nitrogen Cloud

The Wonders of Physics 2022

“Physics of the Olympics”

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

Lights: Main Lights only

Audio: Science Songs

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

(ON B) - RGB {T1 Computer 1}: PPT intro (Who will prepare this?)

Lights: Change to Stage & Floods

Peter: Welcome to the (329, 330, 331, 332) presentation of *The Wonders of Physics*... Before the show begins, I want to assure you 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.)*

Peter: As the Chair of the Olympics Committee, I'm charged with finding a location to host the 2034 Winter Olympics, and we have had a very unusual proposal from a group of physicists at the University of Wisconsin-Madison. Here to explain their proposal, representing the University, is that olympic oligarch, that powerhouse of physical prowess, that wizard of winter, that wonder of physics, Professor Clint Sprott...

Audio: Theme music

Action: [Sprott jogs in wearing a white tuxedo with a lighted torch, ignites a methane-filled balloon, and hands the torch to Peter]

(ON B) - {Lectern Computer 1 - PPT Slide #2}: {..Video of Fire..}

Sprott: Welcome to *The Wonders of Physics*! We in the Physics Department at the University of Wisconsin watched the recent Winter Olympics with great interest, and we noticed how much physics the athletes used in their sports. We think the Olympics could be greatly improved with a few minor changes to the rules and with some additional events that should be very popular. Also, what better place to hold the Winter Olympics than Madison, Wisconsin with its winter weather, frozen lakes, sunny skies, and a world-class university with a superb department of physics.

Peter: The Olympics is about sports, not about physics! But I would like to hear your proposal...

Sprott: Of course. Most of the Olympic events involve motion, and that's the oldest and one of the most important branches of physics. Here to explain some of our ideas is our Master of Motion, Terry Craney...

Motion (Terry [Mic#3] & KH [Mic #4])

Audio: ??????

Terry: Thank you Professor Sprott. Yes, I am the "Master of Motion" and I am here today with my accomplice, Katie, the "Eminence of Energy."

KH: Hello everyone!!! It is I, Eminence of Energy! I hope you're ready to get this show moving because we are here to introduce some new events for this year's Olympics! we're excited to introduce how the fundamental principles of motion and mechanics will bring this year's Olympic games to life! SO, let's get started!

KH: But before we unveil our first event, a little background on the physics.

KH: Here we have two solid (*be sure to emphasize this!*) steel balls of different weight and diameters. First, I am going to drop these balls – now you folks are pretty smart, which **one** do you think will fall faster? **Ready to find out?** (*Drop onto a foam mat*) if you said they fall at the same speed you're absolutely correct! TIME for a harder question, let's roll the balls down this incline. **Now** which ball will reach the bottom first???

{ Input from audience. }

Demo: *{..Steel Ball Down an Incline...}*

Audio: *Ta Da*

KH: WOW, they rolled at basically the same speed!

Terry: Ok, so far pretty straight forward. Two objects of the same shape, but of different masses, both fall and roll at the same rate due to the effects of gravity. But now let's take two different objects – a wooden wheel and a steel rim. Which one of these will reach the bottom first?

{ Input from audience. }

Demo: *{..Wooden Disk Down an Incline...}*

Audio: *Ta Da*

KH: What?! The wooden wheel rolled faster? Why is that Master of Motion??

Terry: It all has to do with the shape of the object and with your namesake “Energy”. Both the wheel and the rim have potential energy or stored energy at the top of the ramp, since they’re both the same distance above the table. As the wheel and rim roll down the ramp, the potential energy is transferred into energy of motion or kinetic energy.

KH: AHHHH I see! But there are two types of kinetic energy here, straight line kinetic energy and rotational kinetic energy. **And here is the difference** – the rim has what is called a higher moment of inertia because of its shape. If an object has a higher moment of inertia, it takes more energy to roll it.

KH: What this is saying is that, more of the original potential energy at the top of the incline goes into rotating the rim and less energy goes into making it travel in a linear direction, thus making it travel down the ramp at a slower linear velocity. Basically, more weight at the center means you’ll rotate faster and go down the ramp faster!

Demo: {..Rotating Platform...}

Terry: Yes, so let’s demonstrate this fact another way with this rotating platform. Eminence of Energy is going to stand on the platform and I am going to spin her around. She holds these weights at arm’s length and then brings the weights into her chest, thereby lowering her moment of inertia and increasing her rotational speed. She then jumps into the air!! and lands perfectly! If not a bit dizzily. —

Audio: Ta Da

KH: I’m no professional skater but, using this physics concept we propose a new modification to Olympic skating: add weights to the sleeves of the skaters! By doing this, we believe a skater could get 5, 6, 8, or even 10 rotations if the skater spins fast enough and the weights are heavy enough (well maybe 10 is a stretch– wink, wink)

Terry: Now that our Eminence of Energy has regained her footing, Let’s talk about another concept called the center of mass or center of gravity. The center of mass of an object is the point at which, for mathematical purposes, and in physics equations, we can assume all of the mass is acting. There are several ways of finding the center of mass of an object. We are going to describe two ways.

KH: To demonstrate, Let's start with this meter stick.

Terry: *{..interrupts..}* – By the way, did you know that the manufacturer of this meterstick is not going to make them any longer?

KH: Cough cough * Bad joke Master of Motion... But anyway, we can find the center of mass of a one dimensional or two-dimensional object by simply balancing it. This stick is fairly uniform, so the center of mass is going to be near the 50 cm mark.

Demo: *{..Center of Mass...}*

Terry: So now let's look at another object. We have here two different size balls attached by a thin rod. This is not uniform so where do you think the center of mass is? Not in the geometric center, but closer to the large sphere. A second way to find the center of mass of an object is to spin it. An object's center of mass is the point around which the object uniformly spins.

Demo: *{..Spin rod at geometric center and at center of mass...}*

Audio: *Ta Da*

Terry: By the way, sometimes this apparatus is called the Earth/Moon demo. But the demo is not to scale. We say the moon revolves around the earth. But actually, and here is a fun fact, the center of mass is about 1000 miles or 1600 km below the surface of the earth. That's the point of rotation.

KH: *Second joke* - Speaking of kms, Did you hear about the guy who named his dog 5km? That way he could say he walks 5km everyday" (wink wink)

Terry: Finally let's look at this hammer. The center of mass of this hammer is here at the "X". *(balance it)*. Now, I am going to attach this light at the center of mass and throw it up in the air. (One revolution, try two, maybe three).

(ON B) - *{Lectern Computer 1 - PPT Slide #?}: { ..??Video of Hammer??}*

Demo: *{..Center of Mass - Hammer!...}*

Audio: *Ta Da*

KH: WOAH! You really set that hammer in motion! Using this idea, we propose that we make ax throwing an Olympic sport.

(ON B) - {Lectern Computer 1 - PPT Slide #?}: { ...Video of Ax Throw...}

KH: This could be a great addition!... That is as long as everyone wears hard-hats and medical personnel are close by, of course.

KH: Now let's look at the idea of friction and another new event we propose. I have a tapered wooden stick. The friction between two surfaces depends on two main factors; one, the types of surfaces in contact with each other, since any two surfaces have a value called a coefficient of friction. And two, the weight or force pressing those surfaces together. To demonstrate, I will blindfold myself and use only the physics of friction to find the center of mass.

Demo: {..Center of Mass - Meter Stick...}

Terry: The types of surfaces are consistent: skin and wood, so the coefficient of friction is the same. The only variable is the weight or force on each finger. So, when the thicker end of the stick rests on her left finger, the weight is more and therefore the friction is more. On her right finger, the stick is thinner so the weight is less and the friction is less, so the right finger slides first until the weight on each finger becomes equal. The fingers then slide in unison until they reach the center of mass. (KH takes off blind fold, holds up meter stick, and bows. Hopefully the crowd will clap and it will act as our transition to the next bit)

Audio: Ta Da

Terry: Here we have a puck with a small battery powered fan in it. The fan pushes air out the bottom to make the puck float on a thin layer of air. The coefficient of friction between the puck and the air is very low, almost negligible. Even though the puck has weight, the friction is very low and will glide almost unhindered.

KH: In the olympics, we propose using this type of air puck to play summer curling! By doing so on a flat, smooth wooden field we should be able to generate a lot of speed on the puck. As you can see, I myself am considering competing in this event! *(Add target on floor. red and white duct tape KH aims at target)*
“ahh I missed haha let's move to the next event shall we?”

Terry: Let's talk about air pressure. Here on the surface of the earth, we all have air surrounding us. That air goes up several hundred miles, with the most dense air in the first 10-20 miles. And although air does not weigh very much, that much air above us does create a significant force. That weight or force spread over an area creates a pressure. Air pressure acts in all directions and on the surface of the earth is equal to just less than 15 lbs./in² or PSI.

{bring audience member down}

KH: Here we have a half sphere, or Magdeburg hemi-sphere, named after a town in Germany where the first demonstration took place. It is exposed to 15 lbs./in² of pressure, 15 PSI on the inside and 15 PSI on the outside. Now if we take the two Magdeburg hemispheres and place them together (be dramatic here) Well we actually– still have 15 PSI both inside and outside-which we can see because they fall apart. However, let's hook them up to a vacuum pump and evacuate the air inside. Now we still have 15 PSI pushing in but basically zero PSI pushing out.

Demo: *{..Magdeburg Hemispheres...}*

KH: Alright! Now that we've evacuated the air inside, I need a volunteer!!!! you, yes you sir you look like a worthy contestant! What's your name?? Alright so, now on the count of three, I want you to try and pull these two hemispheres apart. HMMM let's see if we can pull it apart together.(i grab one end,) still nothing!

Terry: The trick is to turn the valve thereby releasing the pressure!

KH: HEY! Look at that! They came right apart! Everyone! Give Bruce a hand. (as Bruce sits down) pretty cool right?!

{Release valve and hemispheres fall apart.}

Audio: *Ta Da*

Terry: So, here is our proposal. Instead of straight weight-lifting with a bar and added weights, we add a strength event where the athlete has to pull apart Magdeburg hemispheres – starting with a 4-inch diameter sphere needing about 185 lbs. of pull in each arm, going up to a 6-inch diameter needing over 400 lbs. in each arm. That's some heavy-duty pulling and only using the arms.

KH: Finally, let's talk about the reaction time of a human. Reaction time is defined as the time delay between an action happening and a person physically reacting to the event.

Terry: For most people, the reaction time is less than a second depending on the event. For example, the time it takes for an alert driver to move their foot from the gas pedal to the brake of a car is around .75 seconds . Reaction times can easily be affected by age, lack of sleep, or too much caffeine. And can be dangerously long in the case of a driver under the influence of alcohol.

Terry: So, we need a volunteer to help find their reaction time to a free-falling object. (Ask name) Demo- dropping of half dollar bill. We have already done the reaction time calculation for this demo using the above equation and it turns out you need to have a reaction time of less than about a tenth of a second.. Most people's reaction time for this event is between .15 to .30 sec. - Occasionally someone will catch it but very seldom (usually anticipating the drop). Now let's try it using the full dollar bill. Wow, you caught it. The reaction time needed here is less than about two tenths of seconds– a doable time. Thank you, (name), for being a good sport and keep the dollar as a prize.

Demo: {..Reaction Time..}

{Calculate using}

$$t = \sqrt{2x/g}$$

Audio: Ta Da

KH: We believe a new event where we find the fastest reaction time of trained athletes would be quite exciting. Anyone can participate!

Terry: So as you can see, Peter, these new events added to the Olympics in the physics areas of motion, force and energy would be exciting and dynamic. They would show off skills and add to the games.

[Terry walks out]

Audio: TaDa

Peter: That was a “moving” presentation, but how can you be sure the weather in Madison will be good for the games?

Sprott: I'm glad you asked. The Physics Department just hired its own meteorologist to coordinate The Wonders of Physics program and do our traveling shows. Direct from her previous job forecasting the weather on our local Channel 3 and the newest member of our team is Haddie McLean...

Heat (Haddie [Mic #5])

Lights: *Spotlights only { On Peter }*

Peter: It's not possible to control the weather

Audio: ????????

{Haddie appears}

[Adiabatic Cloud section]

Haddie: Oh, I am aware of that! Sometimes you forecast snow, and Mother Nature has her own plans. I can make a cloud, though. And we all know you need clouds to get snow. So, if the host city is low on the white stuff, they just need to turn UP the temperature. That's right, I said heat things up. I am the Temperature Tamer, after all.

Haddie: For demonstration purposes, the air in this empty water bottle will represent the air around the ski slopes or wherever the snow is needed. To make a cloud, you need the water vapor in the air to condense into water droplets. That happens naturally when air rises and cools. It helps if there are tiny particles in the atmosphere for the water to condense on. We call these condensation nuclei.

Mm

Demo: *{..Adiabatic Cloud..}*

Haddie: Today, I'll use ethanol instead of water as it evaporates more quickly. Instead of cooling the molecules by having them rise in the atmosphere, I will change their temperature in a different way, by altering their pressure.

(ON B) - {Lectern Computer 1 - PPT Slide #?}: Pressure vs. Temp (from Haddie)

Haddie: Increasing the pressure in the bottle will increase the TEMPERATURE of the vapor molecules. Then, when the pressure is released, the molecules will quickly COOL down and condense.

Audio: *Ta Da*

(ON B) - {Lectern Computer 1 - PPT Slide #?}: Falling Snow gif

Haddie: So, the host city just needs to put a bubble around the areas that need more snow and

input some condensation nuclei, increase the air pressure and then release. Voila! Huge cloud which could lead to precipitation and more snow!

Haddie: Hmm...there is still some ethanol left in the bottle. I wonder what would happen if I burned it. Wow! I could use that power to help the athletes in another way.

[Ethanol Rocket section]

Haddie: Let's switch gears from skiing down the slopes to speeding across the ice. Olympic speed skaters reach speeds of 35 mph after thousands of hours of practice. But using physics, I think they could go even faster with very little additional effort! Last week, I talked to our very own hometown Olympic gold medalist speed skater, Casey Fitzrandolph. Let's see what Casey has to say about my idea!

(ON B) - {Lectern Computer 1 - PPT Slide #?}: { Casey Video}

Haddie: Now, this idea took some refining, but I think I've gotten it to a place where it can really be used in competition. My first idea was to attach a bottle without a cap to the speed skater. Let me show you.

Demo: { Ethanol rocket w/o cap } (Peter extinguishes fire if necessary)

Audio: Ta Da

Haddie: Wow! That's quite a big flame and we don't want to sear the skater. Some modifications are needed. We need to reduce the amount of flame from the end of the bottle. If we use a cap with a small hole in it, we can reduce the flame and make our rocket safer for the athlete.

Demo: { Ethanol rock w/cap }

Audio: Ta Da

(ON B) - {Lectern Computer 1 - PPT Slide #?}: Bernoulli

Put up net

Haddie: A twist on volleyball, thanks to our friend, [Daniel Bernoulli](#), a mathematician from the 18th century. He discovered a very important relationship between the velocity (or speed) of a fluid and its pressure. The Bernoulli principle states that the pressure of a fluid decreases with an increase in velocity. Remember, air is considered a fluid. So, fast moving air creates low pressure relative to the atmospheric pressure around it. This is the science behind the airplane wing.

[Bernoulli Ball section]

(ON B) - {Lectern Computer 1 - PPT Slide #?}: Bernoulli Principle (from Haddie)

Haddie: I can demonstrate that principle with this funnel. Pushing air through the funnel creates low pressure at the neck of the funnel. High pressure under the ball will keep the ball inside. This works with the funnel facing up or down!

Haddie: But, what does this have to do with the Olympics? Using the Bernoulli principle, I introduce you to a new version of volleyball, called Bernoulli Ball! A good battery-powered leaf blower and a beach ball are all you need to get into this game. The best players will have a solid knowledge of physics, giving them complete control of the ball to conquer the court in no time.

Demo: { Bernoulli Volley-beachball }

Audio: Ta Da

Turn IR Camera on, take down net, move screens in place

[IR Hide & Seek section]

Haddie: And now, as the resident Heat Harvester, I proudly introduce you to the latest and greatest thermodynamic challenge, Infrared Hide and Seek! This game is perfect for the longer winter nights of our cold climates as visible light is not needed. Infrared light is invisible to the human eye but easily detected with an IR camera like this. It detects the thermal energy emitted by an object and converts it into an electronic signal.

Haddie: Let me show you how this works. Will you be my volunteer? I want you to place your hand on the table for a few seconds. Now take your hand away. I'll point the IR camera at the table where your hand was. Look at that! The camera is detecting thermal energy left by your hand!

Video: Table 2 Video 1 { IR Camera - Hand! }

Demo: { IR Screens }

{ volunteers }

Haddie: We have three screens here, each of a different material. I need three volunteers to come and pick a screen to hide behind. Which will you choose? Which will hide you from the IR camera?

And the gold medal goes to _____ behind the plexiglass! _____ behind the screen gets the silver, and _____ behind the black plastic is awarded the bronze medal.

{ volunteers go back - Thank you }

Audio: Ta Da

[Turning Copper to Gold section]

Haddie: Winning a silver or bronze medal in the Olympics is impressive, for sure, but wouldn't it be better to have a gold medal?

Haddie: Well, I can fix that! We just need to use a heated mixture of sodium hydroxide and zinc. First, copper is coated in zinc, then, here's the thermodynamic part, we add heat. In just a short time, you have a medal that looks like gold!

Demo: { Turning copper to gold }

Haddie: Now, this is going to take a few minutes. While we're waiting, let's move on to the next demonstrator.

Peter: OK, those are "cool" ideas, but I don't know how "sound" they are!

Sprott: I'm glad you mentioned "sound" since that's an important area of physics. To explain how the physics of sound could be used in the Olympics, I present from The Physics Experience, our Director of Deafening, Mike Randall...

PSound (Mike R. [Mic #6])

Mike R: (*voice offstage, LOUD*) Are you ready for some
DEEECCCCCIIIIIBBBBBBEEEEELLLLSSSS?

Lights: *Spotlights only { On Peter }*

Peter: What the heck....?

Lights: *All*

Audio: *?????????*

{Mike R. Appears}

Mike R: (*entering stage, LOUD*) Yes, it is !! Mike Randall! The Director of Deafening! Boss of Booming! Captain of Cacophony! Chieftain of Clamor!

Sprott: (*annoyed*) AHM!

Mike R: Pioneer of Pandemonium! Executive of Ear-splitting! Herald of Hullabaloo!

Sprott: (*annoyed*) ENOUGH! We get it!

Mike R: Oh, sorry Professor Sprott! OK! There are a wide variety of sound-based games that participants can compete in.

(ON B) - *{Lectern Computer 1 - PPT Slide #?}: { Presion Gif }*

Mike R: But what IS sound? Sound is created when something pushes and pulls on stuff, creating waves of energy called vibrations. The vibrations travel through stuff to our ears. The stronger the vibrations, the louder the sound. Whatever stuff the sound is traveling through is called the medium. Typically, the medium is air, but it can be any solid, liquid or gas.

Demo: *{Range of Hearing}*

(ON B) - *{Table ?? Computer 1 - O-Scope}*

Audio: Sound from Function Generator

Mike R: How often the waves hit our ears is called the frequency or pitch. Frequency is usually measured in waves per second, or Hertz. Our first contest is to see who can hear the highest frequency. And you can all compete! Here's a sound:

(Turn on sound generator at 400 Hz)

Mike R: Raise your hand if you hear that sound! Keep your hands up. I'm going to start increasing the frequency.

(Slowly increase the frequency)

Mike R: There's an upper limit to the highest frequency you can hear, and it's different for everyone. Lower your hand when you can't hear the sound anymore.

(Keep increasing the frequency. Watch audience hands in auditorium and online)

Mike R: Be honest! Lower your hand as soon as you stop hearing the sound! We have a winner!

Audio: Ta Da

Mike R: Sorry...this isn't the ACTUAL Olympics, so no medal for you. But well done!

Mike R: The speed of sound is FAST! Sound waves can travel 343 meters in one second! That's the length of almost four football fields! BUT, the speed of sound isn't constant! Another Olympic event could be who can make a sound wave travel the fastest.

Mike R: You see, 343 meters per second is the speed of sound in air. Dry air. At sea level. At 20 degrees Celsius (which is 68 degrees Fahrenheit). Things like humidity, temperature and air pressure all affect the speed of sound. And remember, sound can go through ANY stuff: solids, liquids AND gases!

Mike R: In general, the speed of sound in a medium depends on how stiff - or rigid - the medium is. Or, in the case of gases, how compressible it is. The more rigid (or less compressible) the medium, the FASTER the speed of sound.

Mike R: The speed of sound also depends on density: how much stuff - or matter - is in a given volume. For example, styrofoam has a low density and lead has a high density.

(Show equally sized pieces of lead and styrofoam on a balance scale)

Demo: {Scale with Lead & Foam}

Mike R: The greater the density of a medium, the SLOWER the speed of sound.
Now, to demonstrate our competition! Look at these two ropes.

(While talking, Mike uses a grab stick to push the alcohol rocket out of the way towards stage left, and places folded index cards over each rope - green on top, red on the bottom)

Demo: {Wave Speed in Ropes}

Mike R: These ropes are at the same tension. But the bottom rope is nine times heavier. If I hit both these ropes at the same time, it will make waves that will travel on the ropes across the room. Will one wave be faster than the other? Or will they both arrive at the same time? OK, OK, hold on to your guesses. By the way, when a scientist guesses an answer, they call it a hypothesis. Then they do an experiment to see if their guess is correct. OK scientists! Keep your eyes on those index cards at the far right. Notice which one jumps off first!

(Mike hits both ropes simultaneously with a yardstick near the stage right end)

Audio: Ta Da

Mike R: Was your hypothesis correct? The wave traveled faster in the top rope! Why? Remember, the bottom rope has nine times the mass for the same length.

(ON B) - {Lectern Computer 1 - PPT Slide #?}: {Slide, "Wave Speed equation"}

Mike R: If we do the math, the speed of sound in the top rope is THREE TIMES as fast as the bottom rope!.

Mike R: So, competitors in this Olympic event would send sounds through the lightest, most rigid stuff they could find to win the race!

Mike R: Some of you may have been wondering about the OBVIOUS Olympic event: the LOUDEST sound! Personally, that was MY first choice. But the UW-Madison Physics Olympic Committee said NO for safety reasons. Let me show you why an event with loud sounds might be a problem.

Mike R: This is a balloon filled with a mixture of hydrogen and air. When I light it on fire, it will

make a REALLY loud KABOOM. We're going to measure how loud the sound is with this meter.

Demo: {Hydrogen/Air Mixed Balloon (alternate: discharge cap through aluminum strip) }

Mike R: SERIOUSLY! SERIOUSLY! When I tell you to, COVER YOUR EARS! If you're listening with earbuds or a headset at home, TAKE THEM OFF!

Mike R: OK, I'm starting the countdown. COVER YOUR EARS! 5 - 4 - 3 - 2 - 1

(Detonate hydrogen - air balloon, or discharge cap through aluminum strip)

Audio: Ta Da

Mike R: WOW that was LOUD! Let's see what the sound meter measured. It says the sound level was ____ decibels!

(ON B) - {Lectern Computer 1 - PPT Slide #?}: {Slide, "Hearing Range for Humans"}

Mike R: Where on this chart would that sound be? That's really LOUD!

Mike R: By the way, your ears are AMAZING! The loudest sound you can hear is about a TRILLION times louder than the quietest sound you can hear. BUT - as you can see in this chart - the louder the sound, the more likely you are to damage your ears. That's why I wore hearing protection, and you covered your ears!

Mike R: At 120 decibels, without hearing protection, the sound is so loud it HURTS!

Mike R: Big deal! So far, all we've proved is that competitors and spectators for the Loudest Sound event would be required to wear hearing protection. But that's not the whole story...

(ON B) - {Lectern Computer 1 - PPT Slide #?}: {Slide, "REALLY Loud Sounds!"}

Mike R: Sounds can be louder than 120 decibels. Much, MUCH louder! You will have severe pain at 140 decibels, and your ears will break at 160 decibels!

(ON B) - {Lectern Computer 1 - PPT Slide #?}: {Slide, "TWoP 2022 - sound photos"}

Mike R: Not to mention that, if you REALLY, REALLY wanted to win the event, you'd need to do something REALLY LOUD. Like set off a big atomic bomb. Or crash a meteor onto the

Earth. Or blow up a volcano! Scientists believe the loudest sound ever heard by humans was the eruption of the Krakatoa volcano in 1883. They estimated the sound level was 310 decibels. ***That's 10... times a BILLION...times a BILLION times louder than our threshold of pain!*** Even 99 miles away, the sound level was estimated to be 172 decibels - ***almost 160,000 times the pain threshold!***

Mike R: I have to admit, as much as I like LOUD SOUNDS, I don't think I would want to compete in the Loudest Sound event. Or be a spectator! Or even be on the same planet!

(Haddie entering stage)

Haddie: Hey Professor Sprott! Here's your new and improved bronze medal! Now it's golden. Congratulations!

Sprott: Thank you Haddie! And Mr. Randall, thank you for your demonstrations.

Audio:

{Mike and Haddie run offstage}

Peter: Yes, all those ideas are quite "sound" but electricity and magnetism??? These are the Olympic games, and I'd be "shocked" if anything from E&M could be added to the "current" events.

Sprott: Peter, don't be so "negative." I'm positive that our electromagnetic team has some attractive ideas. To tell you about them is our Chairman of Charges, Professor Michael Winokur

Electromagnetism (Michael W [Mic #3])

Lights: Spotlights only { On Peter } ???

Audio: ????????

{Michael Appears.....yelling... "Charge....."}

Michael: Oh ye of little faith, if it weren't for the underlying electrical Coulomb forces the games would simply collapse. I'm sure we can light up these events with an electromagnetic extravaganza.

Lights: All go out. Candle/torch light on presenter (Michael)

Michael: What now, it seems we have a bit of a power outage. But, as they say, the show must go on! I wonder if the Olympic cyclists could power the lights using bicycles attached to electric generators? I am sure they won't mind a little extra training.

Lights: All back on

Michael: One must first ask how power is needed? I looked it up and with modern LED bulbs only about 90 kilowatts are used in a football stadium like Camp Randall. That doesn't sound like too much. Raise your hand if you have been to a night game at Camp Randall.

{We have a slide stating, "What do you think? 20, 60, 200, 600, 2000, 6000"}

Michael: We also need to figure out how much power a cyclist can generate. It just so happens we have a demonstration that will help answer that. All we need is an energetic volunteer.

Demo: Bicycle Electric Generator (choose a volunteer).

{need to figure out how much power is needed and then compare that to what one strong person can generate.}

Michael: Great, and your name is? And do you like bicycling? Our stationary bicycle and generator isn't actually wired up to Camp Randall but just these two 60W bulbs. One is an old fashioned incandescent bulb and the other is a modern LED. Just take your place on the bicycle and, when I give the signal, start pedaling. Ready, set, go.

{first is the incandescent 60W bulb which will get moderately bright}

Michael: Stop. Not especially bright. Let's see how it compares with the LED. Ready, set, go.

{second is the 60W LED bulb which will get quite bright}

Michael: Stop. I think I need some darker goggles. Great job! Thanks for helping! Modern LEDs are up to ten times brighter than incandescent bulbs using the same power.

Michael: Now our helper could probably manage about 100 W at best. And an Olympic cyclist can generate 500 W of sustainable power. Now 90 kW is really 90,000 watts or, doing a little math, 180 cyclists! Nowadays about 600 cyclists attend the Olympics, so it seems like we have a workable plan.

(ON B) - {Lectern Computer 1 - PPT Slide #?}: {Slide of ???}

Michael: That was, ahem, quite illuminating. And now I'd like to know if there are any hockey fans in the audience? You know that old joke....I paid to see the fights and a hockey game broke out. We can't have that. I think an "amped" up penalty would discourage bad behavior. How about using a [Tesla](#) coil equipped penalty box? It might even add a little "spark" to the competition.

(ON B) - {Lectern Computer 1 - PPT Slide #?}: {??}

Michael: Now, a small electrical shock never really hurt anyone. But a big one could so we will have to temporize by using a Faraday cage for the penalty box. But we do need a brave volunteer for beta testing!

Demo: Tesla coil

Michael: Well can you tell us your name? Do you play hockey? And I am also wondering, is your life insurance up to date? No matter, you should be *relatively* safe inside our penalty box. Tesla coils produce high frequency electric currents and so the electrical charges

only flow on the outside of a Faraday cage which is made from a metal conductor.

{Clint mans the Tesla coil control panel}

Michael: Just follow me over to the penalty box and I'll get you situated. To add to the ambiance we even have a chair you can use. It sort of looks like an...electric chair.

Audio: March

Audio: Doom

Michael: Not to worry, we've neglected to attach the electrodes. Just take a seat and get comfortable. Please stay seated until the demo is over. And I also want to point out this fluorescent tube. It will show that there is a very strong electric field on the outside of the cage.

Michael: Professor Sprott will man the control panel. Are you ready? Motor on and energize.

Audio: Ta Da

Michael: How are you feeling? Well that certainly worked out better than last time! Thanks so much for helping out!

Michael: And moving on, have you ever wanted to try your hand at the winter biathlon? Are you the type of person who couldn't hit the ocean from a boat? Fear not, with the power of electromagnets, our new can launcher turns you into a modern-day William Tell
{A short snippet of the William Tell Overture???

Michael: This demo puts an emphasis on the magnetic half of electromagnetism. As James Clerk Maxwell showed, electricity and magnetism are intimately connected.

{The only laws of matter are those that our minds must fabricate and the only laws of mind are fabricated for it by matter.

I have also a paper afloat, with an electromagnetic theory of light, which, till I am convinced to the contrary, I hold to be great guns.

James Clerk Maxwell}

Michael: The can launcher will allow anyone to become a crackpot...excuse me, a "crack" shot. Its operation is almost child's play; that is if your child's name is Maxwell. A brief introduction. This high voltage power supply charges the large orange capacitor. Once we store enough charge, at 50 on the potentiometer, I will suddenly release it and a large rapidly changing electric current will flow through this copper coil. Flowing charges

produce an external magnetic field. And if that magnet field is changing then, by Lenz's law, it will induce an electric current in a nearby metal object...this pop can. That current will produce its own magnetic field which repels the first magnetic field. The up"shot" will be a new type of projectile motion; a real boon for those ballistically challenged.

Michael: We just need a catcher. Ah, I think you will be a great addition to our team.

Michael: Charging...charging....charging....ready, set, launch

Demo: [{..Can launcher..}](#)

Audio: [Ta Da](#)

Michael: Great catch. Well I certainly hope to see you in Milano in 2026

Michael: Whew! After all these high-speed shenanigans, it's time to slow things down, and ensure our skiers, snowboarders and skateboarders have safer landings using our patent pending damping system! As we just saw, changing electric currents can create magnetic forces. Here we show that motion of a permanent magnet next to metals creates a damping force which can slow things down.

Michael: Professor Sprott, do you have the two metallic spheres?

Sprott Of course!

Michael: Only one is a magnet, do you know which?

Sprott That's your job!

Michael: Fair enough. Here I have two pairs of identical tubes. One set is plastic, an insulator, and the other copper, a metal conductor. Let's see what happens when I simultaneously drop them in the plastic tubes. Ready, set go.

Michael: As expected, they both fell at the same rate, plastic is not an electrical conductor. I just wanted to convince our audience that there weren't any tricks. Now for the copper tubes. Ready, set, go.

Demo: [{..Eddy currents..}](#)

Audio: [Ta Da](#)

Michael: We all know which one is the magnet now. The moving magnetic field induces an electrical current in the copper tube and that current has its own magnetic field which generates an opposing force. It even works better in the winter because metals are better conductors when cold!

Michael: The only problem left is how to fit the magnets and metal tubes into the event. I have a graduate student working on that now.

Skipping Theremin for now

Demo: {..Theremin..}

Audio: Ta Da

Michael: Now to speed things back up. For those of you who, ahem, have a more flexible interpretation of the rules, and are prepared to pay top dollar to zoom ahead of your competition, why not adopt our ion propulsion system?

Michael: Ion propulsion is the future of moving fast. How fast? Scientists estimate that ion propulsion could move spacecraft over ten times faster than conventional rocket motors, up to 200,000 mph. Imagine, a 26 mile marathon would be over in a blink of an eye. Well, a terrestrial version wouldn't be quite that fast.

Michael: I can demonstrate how it works using this Van de Graff generator. Notice the four rockets attached to the pivot on top. When I turn on the Van de Graff electrical charge will accumulate on the metal sphere. According to Coulomb's Law, like charges repel and, to get as far away as possible, there will be a large concentration of them on this metal point. This creates an intense electric field and causes the neighboring air molecules to become ionized. Negative charges are attracted and positive ones repelled. According to Newton's third law of motion, there will be a reaction force on the rocket. Let's watch.

Demo: {..Van de Graff..}

Audio: Zoom [as I look to the ceiling]

Audio: TaDa

Michael: There is still one small problem. Ion motors don't generate much force; even the best ion propulsion system generates about 0.1 Newtons of force. So for a 75 kg runner that means after a minute they would, at best, be running just 0.2 mph faster! I'm sure my next graduate student will be able to overcome that limitation.

Michael: Well, it's now time to get my committee presentation ready. Every minute counts.

Peter: I find those ideas a bit shocking for the Olympics, but do you have anything more modern to offer?

Sprott: Absolutely! There have been many recent developments in modern physics. To explain how they can be used in the Olympics is our quantum expert, Mallory Conlon / Shimon Kolkowitz, the Quantathlete!

Modern Physics (Shimon (Sunday)/Mallory (Saturday): [Mics #4])

Lights: All

Shimon/Mallory: I personally think an ion propulsion system is a great idea, but if the chairman won't allow it in the Olympics, maybe we need to think smaller! There are some amazing ways that we could speed things up using the principles of quantum physics. One thing that slows us down when we're sliding on ice is friction... We already heard a bit about friction from the Master of Motion.

[Demo: Superconducting track (racing)] Camera on track

But if we use a special magnetic track, and a special type of material called a superconductor for the skates, we can actually remove most of the friction that will slow down the skater. Let's see how using a magnetic track and superconductor could revolutionize speed skating!

First, instead of ice, we need a special rare earth magnetic track, which has a really strong magnetic field. Then, we'll make the skates out of this special material called Yttrium-Barium-Copper-Oxide. Instead of saying that over and over, we'll just call it our conductor. When we cool down our conductor using liquid nitrogen, which is a really cold -320 degrees Fahrenheit (perfect for the Winter Olympics!), our conductor becomes a superconductor. Superconductors really do not like magnetic fields that come off of magnets like we have in the track. In fact, the superconductor will actually act as a magnet of the same pole and repel away from the magnet! Let's see what this looks like.

Wow, the superconductor is actually levitating above the magnet! As long as the superconductor is cold enough, it will continue to levitate above the track, removing all the sources of friction, except for air resistance of course. Maybe we can have the olympics in space one day! But until then, superconductors could really help speed things up in speed skating! Just think about how fast Casey Fitzrandolph would have gone with superconducting skates! What do you think, Mr. Chairman?

Audio: TaDa

Peter: [shakes his head no]

Shimon/Mallory: Well, if we can't speed things up in our current games to make things more exciting, how about we vote on adding an entirely new game like dodgeball? But to be honest, as a physicist, I've always felt that the Olympics puts too much emphasis on athletic ability and not enough emphasis on math or luck. So this version of dodgeball has some new rules...

[Demo: Switch pitch ball to showcase superposition and entanglement(dodgeball)]

In regular dodgeball, the ball is only one color. But in quantum dodgeball, the ball can be one of two colors, and we only know what color the ball is once it's caught. See, when we throw the ball in the air, it's in a combination or superposition of all its possible colors, both blue and pink. But once we catch it, when we make an observation, we only ever measure one color.

This is how the smallest things in the universe, like atoms and the things they're made of, work! Until we observe them, they can be in a superposition of all their possible states. Then, once we check what state they're in, they have to pick just one. The act of measuring actually changes the state! The outcome of the measurement is probabilistic, not deterministic. There is no way you could know for certain which state you will measure in the end, only the probabilities of each outcome.

So in our version of quantum dodgeball, if you are in or out depends on the color of the ball when it hits you or you catch it. If you're on the blue team and you catch the ball or it hits you when it's pink, then you're out! If you're on the pink team and you catch the ball when it's blue, then you're out! Let me show you how this would work.

Do we have anyone who wants to show how quantum dodgeball works? All you have to do is catch the ball!

If you could stand here, you'll be the pink team, and I will throw this ball to you. If you catch it and it's blue, then you're out! If you catch it and it's pink, then you're safe. But until you catch the ball, you won't know for sure if you're in or out... The ball is in a superposition of both colors, and you are what we call "entangled" with it, so you are in a superposition of being in and out. [[[Ask the audience if she is in or out once she catches it, then do this a few times explaining how the ball is in a superposition of blue and pink until it's caught]]]

So what do you think? Could quantum dodgeball be the next top olympic game, Mr. Chairman?

Peter: [shakes his head no]

Shimon/Mallory: Darn, there goes my shot at a gold medal...

Closing (Sprott [Mic #1])

Peter: Those are interesting ideas, but I think they're a few years ahead of their time. Maybe we could consider them for the 2050 Olympics.

Sprott: Actually, we've already started a competition that would be perfect for the next Olympics. Last year with everyone sheltering at home due to COVID, we sponsored a physics video contest in which some of you submitted entries. The first place entry was from Alex Lie, a high school student in California. Here's his award-winning video:

{Show [Alex Lie Video](#) - 3 minutes}

Sprott: We gave out 18 awards including plaques and prizes. The contest was such a success that we're sponsoring another one this year, and you can all enter. Make a two-minute video illustrating a physics concept, and submit it to our website by June 30th, and maybe you too can be a winner!

{Slide of [Olympic flame](#)}

Sprott: And now, I'd like to conclude our proposal and end the show the same way we've ended every one of the hundreds of shows over the past 38 years by making for you a cloud. It's a very cold cloud as might be appropriate for a future Winter Olympics featuring the principles of physics ...

Sprott: Blah, Blah, Blah ... Thank you all for coming!

{Extinguish [Olympic flame slide](#) as cloud forms}

(ON B) - RGB {Lec Computer 1}: PPT SLIDE # 48 - Clouds / Thank You

(ON B) - DVD Video: Theme music video

Audio: WOP Theme-long-3m22s.wav

Theme music video plays.

{Cast enter and bow in unison.}

Resources:

- [2018 PowerPoint Slide Show](#) (where is the 2019 version?)
- [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](#)
- [2019 WOP script](#) (Steve: Please update these links)
- [2018 WOP script](#)
- [2017 WOP script](#)
- [2016 WOP script](#)
- [2015 WOP script](#)
- [2014 WOP script](#)
- [2013 WOP script](#)
- [2012 WOP script](#)
- [2011 WOP script](#)
- [Free Sound Effects Archive](#)