How Things Work II: Demonstrations

Lecture	Time	Demo Name	Demo Number	Description
1. Intro. & Skating	8:43 – 9:54	Razor Scooter	N/A	Ride on a Razor Scooter, demonstrating the following about skating: When you're at rest on a level surface: - If not pushed, you stay stationary. - If pushed, you start moving in that direction. When you're moving on a level surface: - If not pushed, you coast steadily and straight. - If pushed, you change direction or speed.
	10:59 – 13:05	Pulling a Tablecloth Out From Under Dishes	1	You pull a smooth silk tablecloth out from under a place-setting, leaving the dishes essentially unaffected.
	16:17 – 17:01	A Frictionless Puck on a Flat Surface	2	A puck glides steadily in a straight line after being pushed.
	17:01 – 19:28	Cutting a Banana in Midair	3	A banana dropped from one hand is cut in half by a knife held in your other hand.
	19:28 – 20:48	Cutting a Banana in Midair II	4	You throw a banana horizontally at a knife held in your other hand and the banana cuts itself in half.
2. Falling Balls	2:20 – 6:28; 11:15 – 15:16	Human Animation of Velocity and Acceleration	6	You perform a series of movements that show the students the differences between velocity and acceleration.
	7:13 – 7:35	A Frictionless Puck on a Flat Surface	2	A puck glides steadily in a straight line after being pushed.
	17:22 – 19:24	Comparing the Accelerations of Different Balls	7	A bowling ball is much harder to accelerate than a baseball. (To show how mass affects acceleration).
	19:24 – 20:43	Boxes of Different Mass	N/A	Two apparently identical boxes contain different masses. Without lifting them, one can ascertain their masses by observing the responses to identical pushes. (Shows how mass affects the acceleration due to a force).
	28:20 – 29:33; 31:07 – 31:50	A Ball Falling Up and Down	10	A ball tossed directly upward rises and falls, always accelerating downward in response to its weight.
	30:11 – 31:07	A Ball Falling Downward	8	A ball dropped from rest accelerates downward and eventually hits the floor.
3. Falling Balls II	2:05 – 4:35	Human Animation of Velocity and Acceleration	6	You perform a series of movements that show the students the differences between velocity and acceleration. (Circular motion this time).
	4:38 – 6:00	Uniform Circular Motion – Centripetal Acceleration	57	After a bowling ball is started in a direction, you must continually push the ball toward the center of a circle to make it move in a circular path.

Lecture	Time	Demo Name	Demo Number	Description
	6:26 – 6:46	A Hand Loop-the-Loop	61	A book held in your open palm remains in your palm as you move it in a vertical circle, even though the book is beneath your palm as you pass through the top of that circle.
	17:48 – 23:09	Two Different Balls Fall at the Same Rate	9	Two different balls, having different masses, are dropped from equal heights at the same time and they hit the floor at the same time.
	26:38 – 29:56	A Ball Falling Up and Down	10	A ball tossed directly upward rises and falls, always accelerating downward in response to its weight.
	31:33 – 35:00	The Independence of Falling on Horizontal Motion	12	Two balls fall to the floor simultaneously, even though one ball starts with a horizontal velocity and the other starts from rest. [Note: here, it is only animated and commented upon.]
	43:45 – 44:16	An Object on a Spring or Bathroom Scale	16	Measuring an object's weight with a spring scale (to show that a surface exerts an upward force on an object exactly equal to the object's weight and that a scale reports the upward force it exerts on an object).
4. Force & Work	7:04 – 8:02	Human Animation of Velocity and Acceleration	6	You perform a series of movements that show the students the differences between velocity and acceleration. (Circular motion this time). [Not moving vs. not accelerating].
	13:53 – 15:49	Two People Pushing Each Other	N/A	Two people push on each other (while two scales show how hard each is pushing). The scales read the same values, when they are stationary *or* moving relative to one another. [Illustration of Newton's 3rd law.]
	26:03 – 28:02	Force Exerted by a Ball on a Table	N/A	Question: Can a ball exert a force greater than its weight? Answer: Yes, if there is acceleration involved during the ball/table interaction. (Illustrate by dropping a ball onto a spring scale.)
	34:00 – 39:33	Human Animation of Work and Energy Transfer	17	You raise, hold, and lower a weight to identify those times when you do work – when you transfer energy.
5. Seesaws	0:36 – 10:40	Human Animation of Work and Energy Transfer	17	You raise, hold, and lower a weight to identify those times when you do work – when you transfer energy.
	20:29 – 23:00	Forces and Work on a Ramp	19	A spring scale is used to show that the force needed to keep a cart from rolling down a ramp is much less than the cart's weight.
	37:31 – 38:13	Rotation About Center of Mass	20	Balls and other objects tossed into the air spinning rotate about their centers of mass while their centers of mass fall.
	38:13 – 38:41	Wobble Ball	21	A ball wobbles rapidly back and forth after being thrown upward while spinning.

Lecture	Time	Demo Name	Demo Number	Description
6. Seesaws II	12:00 – 13:16	Angular Acceleration of Different Objects	23	A bowling ball is much harder to spin than a basketball [book version. In lecture, two pipes of equal weights but different moments of inertia are used.] Purpose: to show that an object's angular acceleration depends both on the torque it experiences and on its moment of inertia.
	19:27 – 21:38	A Balanced Seesaw Board	22	A long stick balances when it's supported at its center of mass. (To show that being balanced means experiencing zero net torque and not necessarily being horizontal or motionless.)
	22:50 – 29:03	A Seesaw Board and Some Weights	24	Two identical weights make a seesaw board balance when they are equidistant from the seesaw's pivot. Two different weights make the seesaw board balance when their distances from the pivot are inversely proportional to their weights.
	29:03 – 32:30	Breaking an Egg on a Seesaw	26	An egg sits on one side of a small seesaw and you strike the other side of the seesaw with a mallet. The egg explodes in place.
	32: 00 – 36:38	Two Rulers Tipping Over	N/A	Two rulers, one of double the mass and double the length of the other, are held at the same angle (from vertical) and then allowed to tip over. Q: Which hits first? A: The smaller one, because the force on it is double, but its moment of inertia is 8 times that of the small one (due to mass and distance [squared] from tipping point).
7. Wheels	6:16 – 11:23; 15:23 – 18:00	Sliding Versus Static Friction	27	A box pulled by a spring scale initially resists sliding but eventually slides forward.
	24:29 – 26:14	Wheels – Free and Powered	34	A freely turning wheel spins as you pull it across the table. A turning (powered) wheel pushes itself forward across the table.
	30:26 – 33:04	Forms of Energy	31	A number of objects are shown to contain energy.
	34:04 – 38:40	Forms of Energy – Electrostatic Potential Energy	32	A large capacitor is charged with the help of a string of 9V batteries. It is then discharged with a screwdriver, producing a large spark and a loud pop.
8. Bumper Cars	1:05 – 3:23	Sliding Versus Static Friction	27	A box pulled by a spring scale initially resists sliding but eventually slides forward.
	6:30 – 8:45	Forms of Energy – Electrostatic Potential Energy	32	A large capacitor is charged with the help of a string of 9V batteries. It is then discharged with a screwdriver, producing a large spark and a loud pop.
	12:01 – 13:15	A Box and Rollers	33	A box that slides badly on the table coasts almost freely when it's supported by rollers.
	14:09 – 16:01; 18:10 – 21:20	Wheels – Free and Powered	34	A freely turning wheel spins as you pull it across the table. A turning (powered) wheel pushes itself forward across the table.

Lecture	Time	Demo Name	Demo Number	Description
	16:01 – 18:10	Roller or Ball Bearings	35	The balls or rollers in a bearing rotate as the inner part of the bearing turns relative to the outer part.
	28:00 – 29:28	Carts on an Air Track	N/A	Carts moving on an air track collide with each other and illustrate momentum transfer and conservation.
	36:37 – 38:21	Throwing an Object – Momentum Conservation	37	You sit on a cart at rest and throw a heavy object. While the object accelerates in one direction, you accelerate in the other.
	38:21 – 40:01	A Fire Extinguisher Rocket Cart	118	You sit on a cart with a modified carbon dioxide fire extinguisher attached to it. When you squeeze the release lever, a jet of gas emerges in one direction and you rocket across the room in the other direction.
	43:24 – 46:57	Twisting a Wheel – Angular Momentum Conservation	38	You sit on a swivel chair and twist the axle of a spinning bicycle wheel. When you change the wheel's direction of rotation, you and the swivel chair also experience a change in your rotation.
	47:09 – 48:33	Changing Your Moment of Inertia	40	You spin on a swivel chair with your arms outstretched and weights in your hands. As you pull your hands inward, you begin to spin faster and faster.
9. Electronic Air Cleaners	0:32 – 2:05	A Diablo – Angular Momentum Conservation	39	You spin a diablo (an hourglass-shaped rubber toy) on its string support and show that, once spinning, it tends to continue spinning steadily about a fixed axis in space.
	8:16 – 9:30	The Direction of Acceleration	41	A pendulum that is released from rest always accelerates toward the point below its support – in the direction that reduces its gravitational potential energy as quickly as possible.
	9:30 – 11:55	A Swinging Pendulum	29	A pendulum swings back and forth, with its energy transforming from gravitational potential energy to kinetic energy and back again, over and over.
	16:31 – 19:04	A Helium Balloon	76	An elastic balloon is filled with air, tied off, and released. It slowly sinks downward. A second balloon is filled with helium. This balloon floats upward.
	27:56 – 28:48	Removing Dust from the Air	235	You clap chalky erasers together and note how slowly gravity removes the chalk particles from the air.
	30:20 – 35:19	Electric Charge and Coulomb Forces	236	Two pith balls hang from threads. One of them is given negative charge by a negatively charged Teflon rod and the two objects repel one another. The other pith ball is given positive charge by a positively charged acrylic rod and the two objects also repel one another. Finally, the two pith balls are carefully brought toward one another. They suddenly draw together and touch, showing that they attract one another.

Lecture	Time	Demo Name	Demo Number	Description
10. Electronic Air Cleaners II	4:10 – 5:40	Using Sliding Friction to Start a Fire	28	A wooden peg is turned rapidly with a bow. Friction between the peg and a board causes them to heat up and begin smoking.
	25:18 – 26:28	Detecting Charge with an Electroscope	237	You transfer charge from a Teflon rod to the foils of an electroscope and they repel outward to indicate the presence of charge.
	26:28 – 28:37	Faraday's Ice Bucket	239	You transfer electric charge to an isolated metal cup and then use an electrometer to look for that charge. You find that it's on the outside of the cup, not the inside.
	29:23 – 31:04	A Van Der Graaf Generator	240	A van der Graaf generator operates like an automated version of Faraday's Ice Bucket. A belt delivers charge into a conducting ball and this charge runs quickly to the outside surfaces of the ball.
	31:04 – 31:32	Launching a Styrofoam Cup	241	A Styrofoam Cup placed upside down on a van der Graaf generator lifts itself into the air.
	31:32 – 31:47	Making the Strands of a Pom-Pom Stand Up	242	A plastic Pom-Pom is attached to the sphere of a van der Graaf generator. As charge accumulates on its strands, they spread outward until the Pom-Pom resembles a dandelion tuft.
	32:04 – 35:05	Making Peoples' Hair Stand Up	243	A person stands on a plastic stool and touches the sphere of a van der Graaf generator. As charge accumulates on the sphere and their body, their hair begins to stand up.
	37:13 – 43:20	Sharp Points and Charge – Lightning Rods	244	When you approach the sphere of a van der Graaf generator with a smooth grounded object, sparks occur. But when you approach the sphere with a sharp grounded object, the sphere loses its charge quietly without any sparks.
	44:23 – 46:45	A Simple Electrostatic Precipitator	247	Smoke drifts upward through a metal can containing a thin metal wire. When opposite electric charges are placed on the can and the wire, the smoke suddenly disappears.
11. Xerographic Copiers	29:10 – 30:12	Harmonic Vibrations in a Plastic Tube	227	You hold an open plastic tube by one end and swing it in a circle. It emits a tone that changes in discrete steps as its speed changes, like the tones of a bugle.
	38:17 – 40:00	Electric Conductors and Electric Insulators	238	A metal rod connected to the foils of an electroscope conduct charge to the foils when you touch the rod with a charged Teflon rod. A plastic rod connected to the foils doesn't conduct charge to the foils when you touch it with the charged Teflon rod.
12. Xerographic Copiers II	30:45 – 31:55	Photoconductors – A CdS Cell	250	A cadmium-sulfide photoconductive cell measures the amount of light reaching its surface.

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	39:35 – 41:12	Forming a Charge Image	251	Charge is deposited on an insulating surface with an array of sharp, electrically charged points. The chare in some areas of the surface is erased with your finger. Finally, felt dust is sprinkled on the surface and it sticks to those areas that are still charged.
13. Magnetically Levitated Trains	12:02 – 12:45	The Forces Between Magnets	252	A bar magnet on a horizontal pivot always turns so that its north pole faces the south pole of a magnet you're holding in your hand, or vice versa.
	17:39 – 17:56	Broken Bar Magnet	N/A	When broken in half the two newly created ends of the bar magnet will attract each other.
	24:59 – 25:42	Generating Electricity – A Coil and Magnet	273	When a magnet moves past a coil of wire, a current flows through the wire.
	26:52 – 27:55	Hanging from an Electromagnet	281	A strong electromagnet hangs from the ceiling. A steel surface is touched to it and it's turned on. The forces between the electromagnet and the steel are so strong that you can hang from the steel without pulling it away from the electromagnet.
	33:18 – 33:45	Magnetic Levitation – First Attempt	254	You place one magnet over another so that the upper magnet is supported by repulsive forces from the lower magnet. However, you must put a stick through the two magnets to keep the upper magnet from falling off the lower magnet's magnetic cushion.
	35:01 – 36:17	Stable, Unstable, and Neutral Equilibrium	121	A plastic track is first bent to form a valley and a marble rolls into the bottom of the valley. The track is then bent to form a mountain and a marble is carefully balanced on top of the peak but rolls of it at the slightest disturbance. Finally the track is made flat and level, and the marble remains wherever it's left along this track.
	38:10 – 38:41	Magnetic Levitation – An Almost Free Bearing	256	A magnetic toy spins above a magnetic base. While it appears that the magnetic toy is levitating, it's actually touching the base at one point. Without that contact, it would be unstable.
	38:51 – 39:36	Magnetic Levitation II	N/A	A top is spun on a magnetic base. The top will float above the base stabilized by gyroscopic effects.
	40:54 – 41:47	Electronic Feedback – Newton's Folly	257	A magnetized metal marble hangs in midair beneath an electromagnet. When you block the electric eye that senses the marble's height, it either falls or sticks to the electromagnet.

Lecture	Time	Demo Name	Demo Number	Description
	44:06 – 46:24	AC Magnetic Levitation – Jumping Rings	258	A small aluminum ring is placed around a group of iron rods that pass through a coil of wire connected to the AC power line. When AC current flows through the wires, the ring is repelled by the coil of wire and leaps upward.
14. Magnetically Levitated Trains II & Flashlights	16:43 – 20:03	AC Magnetic Levitation – Jumping Rings II	N/A	When AC current flows through the wires, the ring is repelled by the coil of wire and leaps upward. In a constant, unchanging field is used, the ring will settle. If you use alternating current, the ring will hover.
	25:44 – 27:11	Eddy Current Pendulum II	N/A	A magnetic pendulum swings freely over a non-conductive surface. But when the non-conductive surface is replaced with a conductive surface the repulsive force between the conductor and the magnetic pendulum slows the pendulum to a stop.
	27:15 – 28:31	Eddy Current Pendulum	259	A metal pendulum swings freely through the pole pieces of an inactive electromagnet. But when the electromagnet is on, the pendulum slows to a stop as it tries to swing through the pole pieces of the electromagnet. If the metal pendulum is replaced with a metal pendulum with slits in it, which hinder the flow of current, the pendulum swings freely through the electromagnet.
	28:41 – 29:51	A Magnet Falling Through A Copper Pipe	260	A small magnet falls incredibly slowly through a copper pipe.
	31:16 – 32:28	Electrodynamic Magnetic Levitation of Magnet on a Spinning Metal Disk	262	A large disk magnet floats above a spinning aluminum disk.
	44:52 – 45:33	Chains of Battery Cells	N/A	A light bulb is used to show that a chain of cells produces a higher voltage raise then just a single cell.
15. Flashlights II	14:21 – 15:49	An Unprotected Filament Burns Up	167	You turn on a light bulb that has had its outer glass envelope removed. The filament burns with a cloud of white smoke.
	23:19 – 24:28	A Simple Circuit with a Battery and Light Bulb	264	You connect a battery and a light bulb with wires and create a circuit. The light bulb begins to emit light.
	28:16 – 29:15	A Simple Circuit with a Battery and Light Bulb	264	You connect a battery and a light bulb with wires and create a circuit. The light bulb begins to emit light. (Special emphasis on the fact that the circuit must be a closed loop.)
	38:47 – 39:01	Switching Battery Terminals in a Flashlight	N/A	You switch the terminals on the battery that is used to light the flashlight. The flashlight still functions showing that it does not matter in this case which direction the electrons are traveling.

Lecture	Time	Demo Name	Demo Number	Description
	41:48 – 43:22	Chain of Battery Cells II	N/A	Reversing the terminals of one of the three batteries in the chain makes the net voltage increase equal to the voltage increase of just one of the batteries.
	44:00 – 45:22	Flow of Electrons in a Generator	N/A	A device that shows the direction of electron flow is put in series between a battery and a crank. When the circuit is closed the electrons flow from the battery to the crank and the crank turns. When the crank is then turned manually, the flow of electrons is from the crank to the battery.
	47:16 – 48:00	A Short Circuit	265	A circuit consisting of 3 batteries and a light bulb is working properly and the light bulb is emitting light. When a wire is connected directly from one terminal of the light bulb to the other, the light bulb dims and the wire begins to glow red hot – a short circuit.
16. Power Distribution	22:09 – 23:57	Ohm's Law	266	A simple arrangement of a variable DC power supply, a resistor, a voltmeter, and an ammeter demonstrate that the current passing through the resistor is proportional to the voltage drop across it – Ohm's Law.
	33:41 – 38:43	Distributing DC Power – Current Trouble	267	A light bulb glows brightly when it's connected to a nearby battery but becomes much dimmer when the wires connecting it to the battery grow longer. The solution to this problem is to use thicker wires.
	45:03 – 47:01	Alternating Current and Transformers	268	An alternating current passes through an electromagnet. When a coil of wire with a light bulb attached to it is lowered over the pole pieces of the electromagnet, the light bulb glows.
17. Power Distribution II	20:46 – 21:38	Step-Down Transformers	269	A step-down transformer is used to heat a nail red hot.
	23:43 – 25:05	Step-Up Transformers	270	A step-up transformer is used to make a flaming arc that rises between two almost parallel vertical wires – a Jacob's ladder.
	25:10 – 26:40	A Tesla Coil	271	An air-core step-up transformer is used to produce long sparks.
	33:31 – 36:09	Distributing AC Power – Transformers Save the Day	272	A light bulb glows brightly when it's connected to a nearby AC power source but becomes much dimmer when the wires connecting it to the power source are longer. While thicker wires help, there is a better solution: step the voltage up for transmission through the original wires and step the voltage down before delivering power to the light bulb. After inserting two transformers into the system, the distant light bulb glows brightly.

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18. Tape Recorders	8:41 – 9:05	Aluminum and Copper are Non-Magnetic	292	While steel sticks to a bar magnet, aluminum and copper do not.
	14:28 – 15:33	Magnetic Domains	290	An array of magnetic arrows (tiny compasses) forms aligned domains.
	15:53 – 16:48	Hard Magnetic Materials	N/A	An array of magnetic arrows (tiny compasses) all shift their poles to align with the magnetic field of a strong magnet in effect magnetizing the material.
	16:49 – 17:27	Demagnetizing a Hard Magnetic Material	N/A	Once the material is magnetized, if the magnet has kinetic energy as it is leaving, here displayed by jiggling the magnet, the material will revert into aligned domains.
	19:00 – 20:30	A Magnet and Steel Nails	291	Steel nails normally don't stick to one another. But when you touch the pole of a permanent magnet to one of the nails, the nail becomes a magnet. When this nail touches another nail, that nail becomes magnetic, and so on. When you remove the permanent magnet, the nails slowly lose most of their magnetizations. (Here steel nails are replaced by paper clips)
	22:58 – 25:38	Reversing the Magnetization of a "Permanent" Magnet	294	A bar magnet is inserted in a magnetizer and its poles are permanently reversed. A second trip through the magnetizer flips its poles back to normal.
	25:50 – 27:33	Currie Point Pendulum	N/A	A nail attached to a string will be pulled toward a large magnet. If the nail is then heated above the Currie Point it will loose its magnetization and fall away from the magnet and swing on its string. As the nail cools below the Currie Point it will regain its magnetization and become once again attracted to the magnet.
19. Review	NO DEMONSTRATIONS			
20. Audio Amplifiers	5:55 – 7:50	Domain Flipping in a Piece of Soft Iron	293	An iron rod sits in a coil of wire that's attached to a sensitive audio amplifier. As a bar magnet is brought up to the iron, the domains inside the iron flip into alignment with the magnet. These flipping domains induce currents in the coil of wire and create a "shoop" sound from the amplifier's speakers.
	7:50 – 8:57	A Simple Tape Player	296	You construct a simple tape player by inserting an iron rod in a coil of wire that's attached to an amplifier and speaker. You then pull a long refrigerator magnet strip across the iron "playback head" and hear a humming sound from the speaker. The faster you pull the strip across the iron rod, the higher the pitch of the hum.

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	8:57 – 10:25	A Reconstructed Audio Amplifier	297	A piece of magnetic tape slides across the playback head of a tape recorder. The amplifier and speaker of the tape recorder reproduce the sound.
	11:12 – 12:23	Sprinkling Iron Fillings on a Credit Card	295	You sprinkle iron fillings on the magnetic strip of a credit card. The fillings align in patterns, indicating that there is a pattern to the magnetization of the permanent magnetic strip. [Also shown with a long refrigerator magnet.]
	22:40 – 23:40	A Speaker	299	A variable-amplitude 60 Hz current flows into a large speaker that rests horizontally on the table. Several marbles in the cone of that speaker begin to leap up and down.
	27:27 – 27:59	Generating Electricity – A Coil and a Magnet	273	When a magnet moves past a coil of wire, a current flows through the wire. (To show that changing or moving magnetic fields can induce currents in electric conductors.) [Electric current shown with a LED attached to the coil here.]
	39:32 – 40:12	Forms of Energy – Electrostatic Potential Energy	32	A large capacitor is charged with the help of a string of 9V batteries. It is then discharged with a screwdriver, producing a large spark and a loud pop.
21. Audio Amplifiers II	26:16 – 28:26	Diodes – One Way Devices for Current	279	A battery and light bulb are connected in a circuit so that the bulb lights up. When a diode is inserted into the circuit in one direction, it has essentially no effect and the bulb remains bright. But when the diode is reversed, no current flows through the circuit and the bulb is dark. [In lecture, alternating current was used on conjunction with red and green diodes (which lit according to which way the current was flowing). A diode could cancel out one of the colors, and a conductor could filter the current into DC so that the light was steadily lit.]
	33:35 – 36:31	A MOSFET	300	You show that a tiny amount of electric charge (delivered with your finger) on the gate of a MOSFET can control the flow of a large amount of electric current between its source and drain. The MOSFET controls a light bulb.
	37:53 – 40:01	An Audio Amplifier	301	You build a simple audio amplifier and use it to amplify sound from a small tape or CD player so that it can be reproduced by a reasonably large speaker. The amplifier is so sensitive that you can act as part of the wiring connecting the tape or CD player to the input portion of the amplifier.

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22. Computers	2:36 – 11:04	Deforming / Destroying a Soda Can	N/A	You take a large capacitor (charged to ~4kV) and discharge it through a coil of wire. Inside the wire is a soda can, in which an induced current deforms or rips apart a soda can when the capacitor is discharged.
23. Computers II & Radios	32:10 – 34:34	Electromagnet	N/A	A powerful electromagnet "grabs" an iron rod, and the student cannot pull it off. When the knife switch is disconnected, a spark is emitted because the magnet acts to oppose the change in a magnetic field.
	36:00 – 41:25	A Tank Circuit	305	You charge a capacitor and then connect it to an inductor to form a tank circuit. As shown by an oscilloscope, the charge sloshes back and forth through the tank circuit in a natural resonance.
24. Radios II	34:05 – 37:50	A Radio Transmitter and a Nearby Antenna	306	A small radio transmitter emits radio waves from its short vertical antenna. A nearby antenna receives those radio waves and uses their power to light a light bulb.
	45:55 – 47:26	Transmitting Radio Waves	307	You turn on a radio transmitter and the static on an FM receiver suddenly disappears – the receiver is silent. When you then begin to FM modulate the transmitted wave, the receiver begins to emit sound.
25. Televisions II	23:43 – 25:00	Fluorescence	310	Various materials are exposed to ultraviolet light and glow different colors.
	34:49 – 36:16	Deflecting a Beam of Electrons with Magnetic Fields	313	A magnetic field created by a hand-held magnet deflects a beam of electrons in a cathode ray tube.
	36:16 – 38:01 39:30 – 40:43	Mixed the Primary Colors of Light	315	By mixing various amounts of red, green, and blue light, you can make people perceive any possible color.
	41:45 – 44:58	Deflecting a Beam of Electrons with a Magnetic Field – in a Black & White Television Set	314	You hold a strong magnet up to a black and white television set and the picture distorts. [Also with a color set here.]
26. Microwaves	39:54 – 45:10	Conductors in a Microwave	N/A	An object consisting of wires pointing into a chamber of neon gas lights u when put in a microwave. So does a light bulb. A CD produces many little sparks because its plastic expands faster than its aluminum when heated, thus pulling the aluminum into little shreds which produce sparks through corona discharge.
	45:18 – 47:30	Fire in a Microwave	N/A	Fire in a microwave produces very bright plasma balls.

Lecture	Time	Demo Name	Demo Number	Description
27. Sunlight	31:28 – 32:36	Sunspots Aren't Really Dark	319	The filament of an uncoated light bulb appears dark against the bright background of a light box or an overhead projector's light source. But when the light box or overhead projector is turned off, the filament is glowing reasonably brightly – just not as brightly as the background.
28. Sunlight II	11:51 – 17:02	The Blue Sky and the Red Sunset	320	You shine light from the slide projector through a tank of clean water. A bright, white circle appears on the screen beyond. But after you add a chemical to the water, the circle gradually reddens, like the setting sun. The colors of light scattered by the water also change gradually from blue, like the sky, to various shades of purple, like those visible in the sunset.
	27:51 – 32:23	Refraction	321	A beam of light passes through a glass or plastic surfaces and bends as it does.
	37:58 – 39:12	Reflection	322	A beam of light partially reflects from the surfaces of glass or plastic.
	41:44 – 42:36	Dispersion	323	A beam of light bends as it passes through a glass or plastic prism, but the different colors in the white light bend differently and a rainbow forms on the screen where the beam finally hits.
	45:46 – 46:51	Soap Bubbles and Interference	326	You blow soap bubbles on the surface of a sheet of white plastic laying on an overhead projector. The soap bubbles exhibit beautiful colors in a darkened room.
29. Fluorescent Lights	17:45 – 22:28	Polarizing Glasses	324	You show that glare, the sunlight reflected at shallow angles by horizontal surfaces, is mostly horizontally polarized. Polarizing sunglasses block this glare effectively.
	30:44 – 33:40	Gas Discharges	328	A vertical glass tube emits a bright line of light as an electric discharge occurs inside it. The colors of this discharge depend on the type of gas inside that tube. A CCD camera views the tube through a diffraction grating and displays a series of bight spectral lines.
	46:55 – 47:48	An Open Helium Neon Laser	333	You observe the spectral liens in the gas discharge of a helium neon laser. Only one of these spectral lines is present in the laser light emerging from a helium-neon laser. [First half of demo.]
30. Fluorescent Lights II	10:38 – 12:23	Invisible Flask	N/A	A flask is put inside a beaker. Its refractive index is almost the same as that of salad oil, so it seems invisible when the beaker is filled with salad oil.

Lecture	Time	Demo Name	Demo Number	Description
	20:11 – 23:40	An open Helium Neon Laser	333	You observe the spectral lines in the gas discharge of a helium neon laser. Only one of these spectral lines is present in the laser light emerging from a helium-neon laser.
	32:42 – 35:04	Different Fluorescent Fixtures	330	You turn on two fluorescent lamps – one with powder inside and the other without. The lamp without powder glows the same color as the mercury lamp, but the lamp with powder blurs the wavelengths into white light.
	36:27 – 39:54	Different Fluorescent Fixtures	330	You turn on several different types of fluorescent fixtures to show how they initiate and control their gas discharges.
31. Lasers	28:39 – 31:44	An Open Helium Neon Laser	333	You observe the spectral lines in the gas discharge of a helium neon laser (or a neon discharge lamp). Only one of these spectral lines is present in the laser light emerging from a helium-neon laser.
	34:34 – 37:00	The Coherence of Laser Light	334	You observe the patterns produced when laser light passes through slits and screens.
32. Cameras	5:58 – 7:26; 11:45 – 15:10	Forming a Real Image	335	While light from a light bulb alone causes a diffuse illumination of a white screen, the addition of a converging lens can form an inverted image of the light bulb on the screen.
	19:31 – 20:15	How a Lens Works	336	You use black board optics (or camera table optics) to show how a converging lens bends light rays together and can thus form a real image of an object.
	26:33 – 28:48; 37:32 – 40:16	Depth of Focus	338 A	A large-diameter converging lens forms real images of three different light bulbs at three different distances from the lens. Only one of these images is sharply focused on a screen at a time. But when a small aperture is inserted over the lens, allowing only its central portion to form the image, all three images are in focus at once.
	30:48 – 33:16;	The Importance of a Lens's Focal Length	337	The real image formed on a screen by a long focal length lens is larger and dimmer than the real image formed by a short focal length lens of the same diameter.
33. Optical Recording & Communications	9:55 – 11:06	Underwater Watch Face Reflection	NA	A waterproof digital watch is placed under water and turned so that the face of the watch becomes reflective.
	28:05 – 30:50	Internal Structure of a Compact Disc Player	NA	You open a compact disc player showing the internal structure and location of the mirrors, beam splitters and lasers.
	35:11 – 36:16; 39:00 – 40:38	Putting Sound on Light (Analog Version)	346	The signal from a tape player is used to modulate the light outputs of a flashlight and a laser pointer. This light strikes an optical sensor that's connected to an amplifier and speaker, and the sound is heard.

Lecture	Time	Demo Name	Demo Number	Description
	43:21 – 45:20	Light Following a Stream of Water	348	A beam of laser light shines into the stream of water leaving a container. The light follows the water as the water arcs downward and illuminates the spot where the water hits a basin.
	46:50 – 47:10	Putting Sound on Light through Fiber Optics	NA	A piece of fiber optic cable is used to link a modulated light to a speaker where the sound is heard.
34. Knives & Steel	8:55 – 12:01	Stress & Strain	N/A	Press on a stack of spongy rectangles to illustrate the concepts of stress and strain.
	13:00 – 14:25	Shear Stress and Shear Strain	N/A	Press on a stack of spongy rectangles to illustrate the concepts of shear stress and shear strain.
	18:00 – 18:56	Paper Slip	N/A	Subject a stack of paper to shear stress – it deforms by having the sheets slip across one another. This is similar to the way steel crystals may slip across each other.
	25:22 – 28:11	Cooling a Lead Bell	N/A	A lead bell doesn't ring very well at room temperature. When you cool it with liquid nitrogen, it rings quite loudly.
	37:26 – 40:00	Ferrite and Austenite	N/A	Because of the different crystalline arrangements of Ferrite and Austenite (iron below and above 723˚C, respectively), a heated iron wire expands, contracts and turns into Austenite, then continues expanding when heated. The reverse happens when the wire is allowed to cool.
35. Knives & Steel II and Windows & Glass	12:08 – 19:18	Hardening and Annealing a Steel Nail	350	You try to bend a hardened steel nail and it breaks. You take an identical nail, heat it red hot, and let it cool slowly. It then bends rather than breaking. You straighten this nail and reheat it. However, this time you plunge the red hot hail into water to harden it. Now it breaks rather than bending.
	30:08 – 32:20	Heat Pack – A Super Cool Liquid	N/A	A heat pack contains a super cool liquid, like glass. When it is perturbed the liquid turns into a solid crystalline material.
	36:05 – 41:28	Melting Glass – Quartz vs. Soda-Lime Glass	352	You try to melt quartz glass tubing unsuccessfully while soda-lime glass tubing melts easily.
		Thermal Shock and Glass	353	You show that heating soda-lime glass rapidly causes it to crack from the stresses of uneven thermal expansion. Borosilicate glass doesn't suffer such problems. Quarts glass can handle rapidly heating, too. Upon rapidly cooling in cold water, even the borosilicate glass may break, but quartz glass is still unaffected.
36. Windows & Glass II and Plastics	9:39 – 11:15	Tempered Glass – Rupert Drops	356	When you break the tail of a small glass drops, the drop crumbles into dust.
	11:15 – 13:00	Tempered Glass – A Bologna Bottle	355	You use a peculiar glass bottle to pound in a nail. You then drop a tiny chip of sharp crystal into the bottle and it falls apart.

Lecture	Time	Demo Name	Demo Number	Description
	38:40 – 41:17	Cellulose Derivatives	359	You show that a piece of nitro cellulose (celluloid) is quite clear and tough, but that it burns nicely. A piece of cellulose acetate (acetate plastic) is much more practical.
	41:17 – 44:00	Glue Putty	361	You mix white glue, water, and borax to create a soft putty that flows slowly like a liquid but that tears when exposed to sudden large stresses.
37. Plastics II and Nuclear Weapons	6:35 – 9:56	Reptation in Wet Cornstarch	360	A mixture of cornstarch and water appears liquid-like when you stir it slowly but feels hard when you poke it suddenly or try to throw it abruptly out of its container.
	20:52 – 24:03	Making Plexiglass	363	Demo was not done, but was discussed (with emphasis on its dangers).
	24:12 – 26:38 28:20 – 28:25	Superglue	265	You squeeze a few drops of superglue (cyanoacrylate monomer) onto a smooth metal surface and press a second smooth metal surface against it. About 1 minute later, it's difficult to separate those surfaces – they are joined by long polymer molecules.
	26:38 – 28:20	Epoxy	364	You mix two liquids and stir them together. About 5 minutes later, you have a solid material.
	32:05 – 33:44	High-Strength Polymers	369	You step into a loop at the end of normal plastic rope that's attached to the ceiling and the rope stretches considerably as it begins to support your weight. You then step into a loop at the end of a high-strength rope that's also attached to the ceiling. It doesn't stretch noticeably.
38. Nuclear Weapons II	18:13 – 20:44	Radioactive Decay	371	You hold a Geiger counter near various radioactive sources and listen to the random nature of their decays.
	20:44 – 24:00	Cloud Chamber	N/A	Watch the "streamers", or paths of particles, emitted from a radiation source in a cloud chamber.
	45:36 – 47:09	A Mousetrap Nuclear Explosion	372	You drop a small rubber ball into a field of set mousetraps, each loaded with two rubber balls. After bouncing around briefly, the rubber ball trips a mousetrap and the whole collection suddenly "explodes" in a shower of bouncing balls.
39. Medical Images & Radiation	No Demos			
40. Final Review	No Demos			