Teacher's Guide for:

Super Strong Magnets

Note: All activities in this document should be performed with adult supervision. Likewise, common sense and care are essential to the conduct of any and all activities, whether described in this document or otherwise. Parents or guardians should supervise children. Rock-it Science assumes no responsibility for any injuries or damages arising from any activities.

NOTE: *This is the transcript of a lesson that was videotaped during an actual Rock-it Science class with real students, not actors. The students' brainstorming comments are included on the video but are not transcribed here because they're not part of the lesson presentation.*

Contents:

Title Page of Video

Super Strong Magnets
A Rock-it Science Lesson
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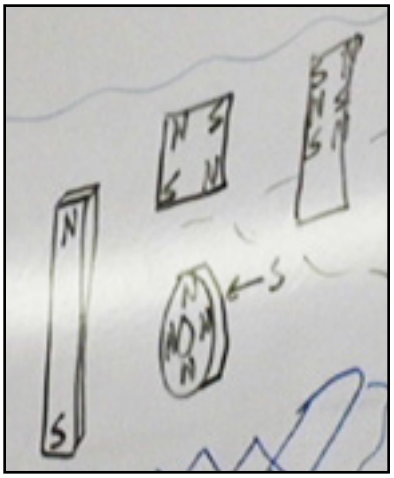
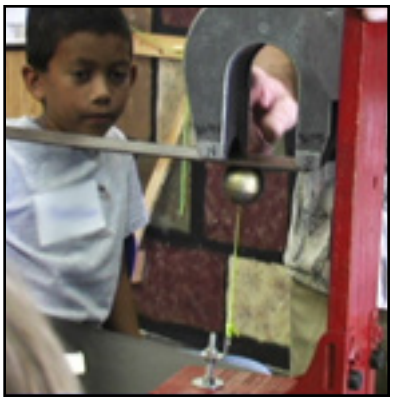
Experiment Quick Recap: *"Super Strong Magnets"*

- Draw different kinds of magnets to show that they can have any shape, and many different locations for the North and South poles. Bar magnet has North on one end and South on the other. A circular magnet could have North on one side and South on the other. A square magnet could have Norths and Souths on alternating corners. A long bar magnet could have alternating Norths and Souths along the length.
- The experiment today will use doughnut-shaped magnets. They're not particularly strong, but we're going to find some way to make them stronger.
- Instructor uses a giant horseshoe magnet with a metal ball that sticks to it. Show students pieces of various materials (cardboard, wood, aluminum, brass, etc.) and ask them which ones will stick to the magnet. Then test each one. The only one of this group that sticks is steel. So the ball is made of steel.
- When the steel plate is stuck to the magnet, the steel ball doesn't stick as firmly, so it's easier to pull it away. That's because the magnet's energy is being robbed by the steel plate.
- If you can get a North to be close to a South, but not touching the South, something weird happens.
- Instructor holds up a doughnut magnet. It has North on one side and South on the other, and they come together all around the edges and around the middle hole a little bit.
- If you put this magnet on a steel plate, it will wiggle the plate a little, but we want to make it really strong.
- Demonstrate a spring scale and show how to connect an angle bracket to it.. Show students how to work in pairs, with one student hooking their finger into the loop at the top of the scale while the other pulls on a magnet attached to the angle bracket. Read the amount of pull in grams on the scale.
- Pass out a scale and an angle bracket to each group, then pass out a doughnut magnet to each group. Let students see how much pull they get on the scale. Remind students to pull by the magnet, not by holding the bracket.
- A few minutes later, Instructor passes out a second doughnut magnet to each group, so they can see if that helps.
- Then Instructor passes out two steel squares to each group and tells students to combine them in some way with the magnets to make them stronger.

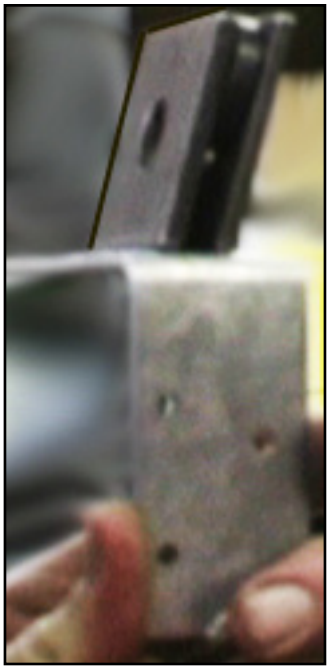


Magnets in various shapes.


Steel plate between ball and horseshoe magnet.


Pulling the magnet.

- After a few minutes, if students don't find a solution, suggest to them that sandwiches are good, but don't show them anything.
- If they still don't find a way to make the magnets stronger, show them how the two doughnuts can be sandwiched between the two square plates. They need to be placed against the angle bracket by their edge, rather than the flat side, in order to work well.
- Suggest that students try arranging their magnets in different ways, e.g., one on top of another; both Norths toward the plate; both Norths on one side; North and South side by side, etc.
- After a few minutes, Instructor collects the magnets and square plates, but students keep the scales and angle brackets.
- Instructor brings out a neodymium magnet from a computer hard drive.
- Caution students about the danger of getting a blood blister if they get their finger between this magnet and a piece of steel.
- When putting the magnet on the bracket, it's best to slide it on sideways. Leave a little hanging off the side so you can hold on to it when you pull.
- Pass out one magnet to each group, giving the thicker ones to the older students.



Round magnets sandwiched between steel squares, attached by the edges to an angle brackert.

- Using the neodymium magnets, the students are able to register five thousand grams on the scale.
- After a few minutes, Instructor collects all of the scales, brackets, and magnets.
- Then Instructor brings out a twenty-five pound weight and places it on a bathroom scale so students can see that it registers twenty-five pounds.
- Instructor shows students an old-fashioned magnet made from four aluminum-nickel-iron bar magnets put together. It was once used in a machine shop to pick up pieces of metal from the floor.
- Instructor places the magnet on the weight to see if it will lift twenty-five pounds. As he pulls up on it, the scale reading gradually gets lower and lower until it hits zero, and the weight lifts off.
- The best to get this magnet off the weight is by sliding it off sideways.

Picking up a twenty-five pound weight.

Equipment List: "Super Strong Magnets"

Items needed for Instructor:

- Giant horseshoe magnet
- Samples of materials: cardboard, wood, brass, aluminum, stainless steel, copper, and steel.
- Weight, twenty-five pounds
- Scale, bathroom
- Magnet made of four bar magnets

Prep Work:

- None

Items needed for Students:

Consumables (per student):

- (None)

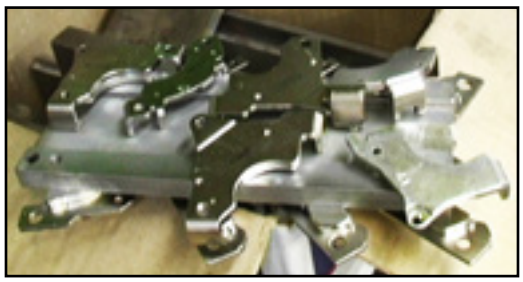
Other (per group of 2 students:

- Scale, spring, up to 5,000 gms
- Angle bracket
- Magnets, doughnut-shaped (2 ea)
- Steel square plates (2 ea)
- Magnet, neodymium

4-Bar magnet.

Spring scale

Doughnut-shaped magnets.



Neodymium magnets.

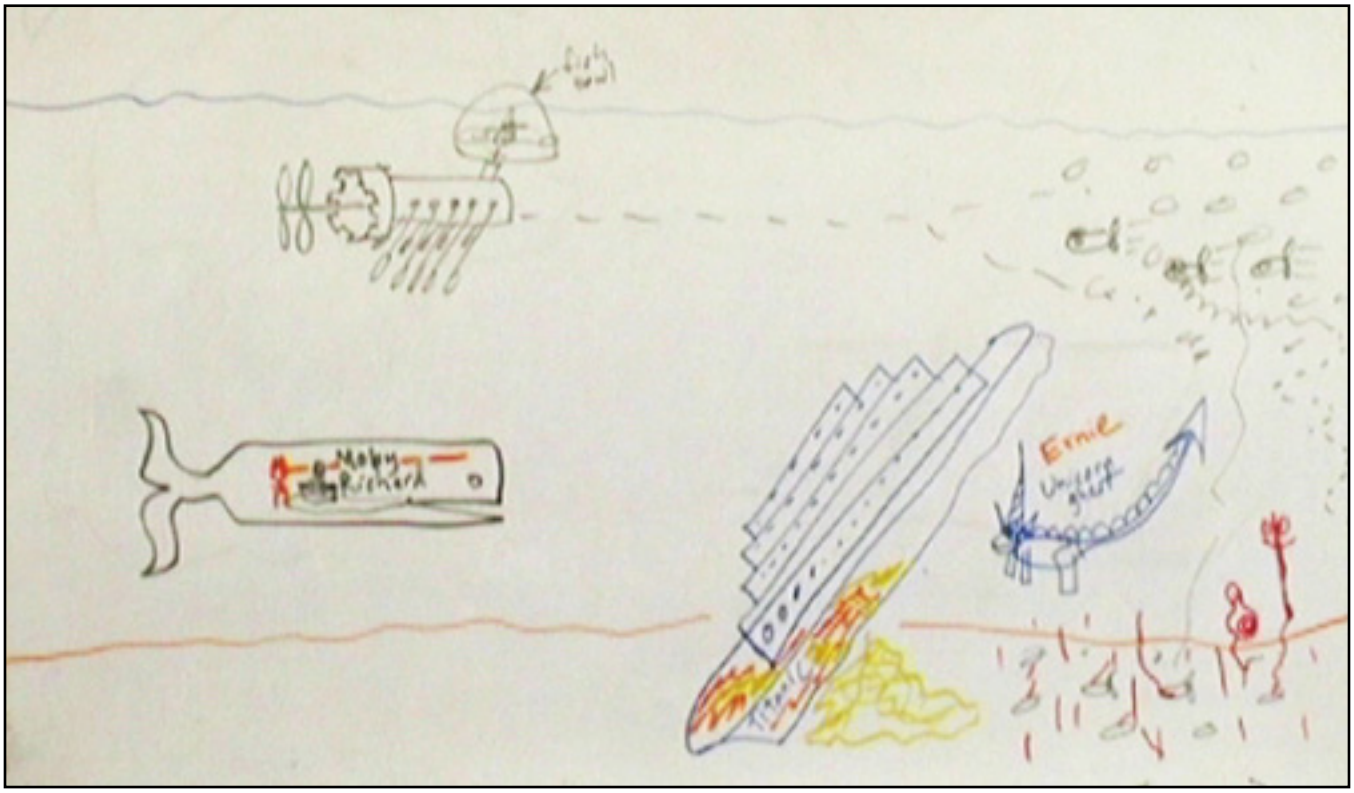
Square steel plates.

Giant horseshoe.

Bathroom scale and 25-lb. weight.

Angle brackets.

Story Recap: "*Jack & Jill and the Unicorn Ghost*"



Part 1:

- There was a ship called the Titanic, and the captain was a unicorn. The unicorn steered the Titanic into a giant whale named Moby Richard, and the whale sunk the ship.
- The unicorn (name Ernie) survived as a ghost, guarding the wreck of the Titanic and its cargo of gold on the bottom of the ocean. Ernie has the body of a hippopotamus and the tail of a dragon as well as his unicorn horn.
- Evil Mister Fred wants to steal the gold, so he's searching for it in his submarine. The propellers on the back of his submarine don't work, so he drilled holes in the sides for oars, and his minions row the boat underwater.
- The minions can hold their breath for about a month, but Evil Mister Fred has a fishbowl on his head so he can breathe.
- Jack and Jill aren't searching for gold; they're searching for Gepetto, who is inside Moby Richard in his rowboat with Pinoccio.
- Jack and Jill and all of their Kick-Mes are in individual submarines, hundreds of them, with windows and propellers.
- When Evil Mister Fred saw Jack and Jill, he told his minions to ram them with his submarine. He missed Jack and Jill's submarines, but crashed into a lot of the Kick-mes' submarines.

- The Kick-mes were tethered to their submarines, so when the subs sank to the bottom, the Kick-mes sank, too. The pressure at that depth crushed them so they became really skinny and long, which was fun for them.
- Jack and Jill need to get their Kick-mes off the bottom of the ocean before they can deal with Evil Mister Fred.
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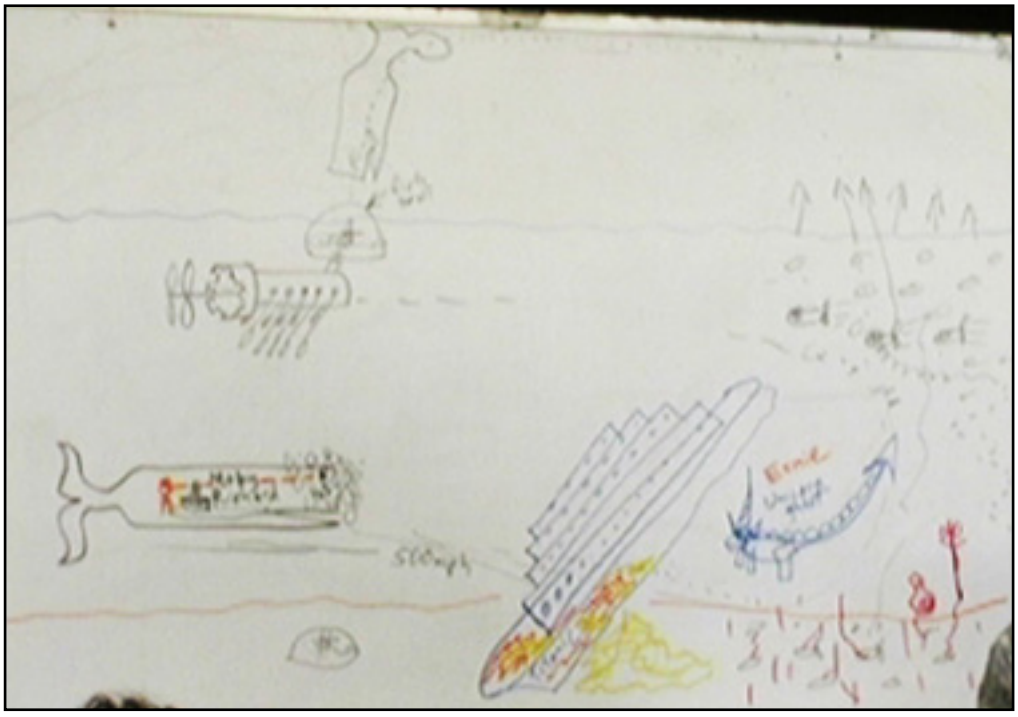
Ending:



- Pinoccio has a long nose, but it's not made out of wood. It's made out of stretchy steel.
- Moby Richard's head is a giant magnet. That's why Pinoccio's nose got longer as he got closer to Moby Richard.
- Jill can talk underwater, so she sends a call to Moby Richard because she wants to use his magnetic head.
- As Moby Richard got closer, he started going faster and faster, so he knew there must be something magnetic nearby.
- Moby Richard weighs about a hundred tons, and as he approached the Titanic, he was going five hundred miles an hour. He hit the Titanic and smashed it.
- All the submarines with Kick-mes got stuck to Moby Richard's magnetic head. Jack and Jill told him to take them to the top.
- Moby Richard zoomed to the surface and leapt into the air. As he did, he turned off his magnetism and released all the Kick-mes.
- When Moby Richard came down, he landed on Evil Mister Fred. Evil Mister Fred got squished inside his fishbowl and got stuck to the ocean floor.

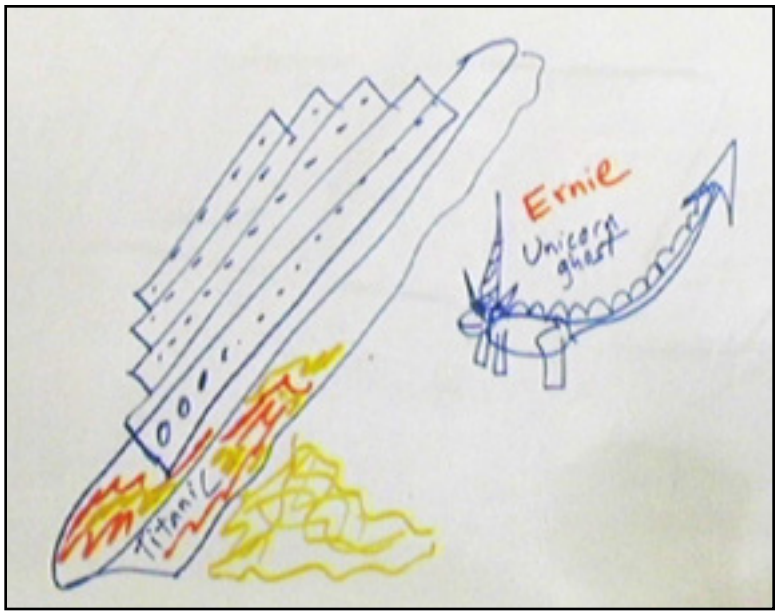
Story: *"Jack & Jill and the Unicorn Ghost"*

[NOTE: There is no introduction. This lesson begins with the story.]

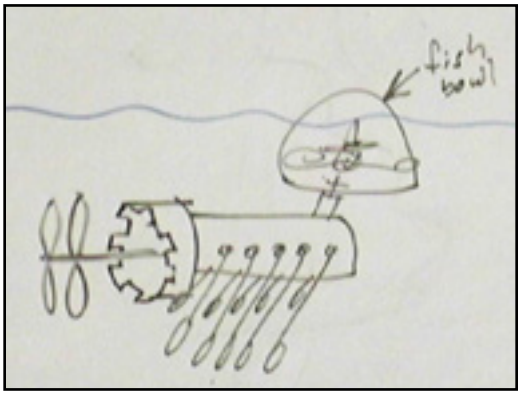
Let's see, we need to take somebody else's story and mess it up completely. And this story has to have an underwater sequence in it, so probably we could take the Pinocchio story and really screw that one up. *[Students: Titanic! A swimming unicorn!]* Titanic? A swimming unicorn? We like unicorns.

Once upon a time, there was an ocean. And there was a ship called the Titanic, and the captain of the Titanic was a unicorn. And the Titanic was steered by the unicorn into . . . I guess it could be an iceberg. *[Student: A giant whale!]* Yeah, it was steered into a giant whale named Moby Dick. And the whale sunk the ship. And the unicorn survived. But the unicorn only survived as a ghost on the old Titanic.

So there's this unicorn ghost here. And he's got the body of a hippopotamus. And he's got the tail of a dragon. And he's got some scales, like that. Unicorn ghost. And the Titanic happened to be taking a whole bunch of gold from Europe to America, so it's full of gold. This gold is leaking out of the broken portholes, so there are big piles of gold all over the place. And the unicorn -- his name is Ernie -- Ernie is protecting all this gold that's on the sea floor. Anybody comes along and they try to steal Ernie's gold, well, he's going to spear them with that thing he's got on his head. And he's protected the Titanic for over a hundred years. Almost exactly a hundred years, very close to it.



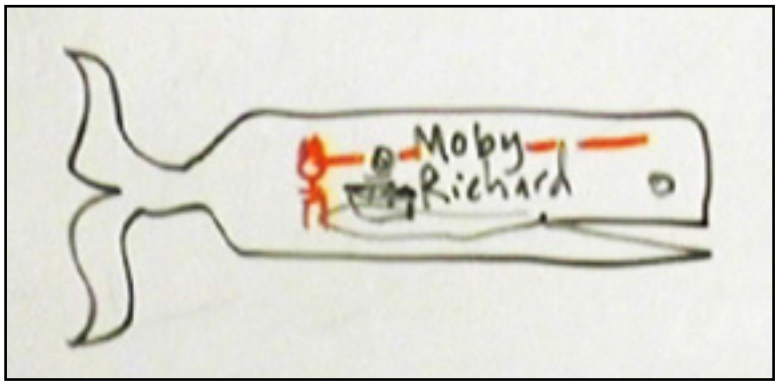
The sunken Titanic, pile of gold, and the Unicorn Ghost.



Evil Mister Fred's submarine.

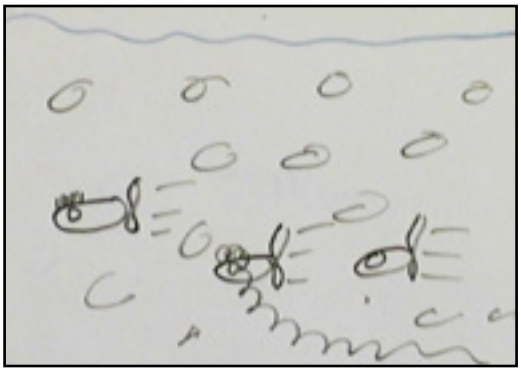
And somebody wants to steal that gold. And Evil Mister Fred has got his own submarine. He's down there searching for the gold. Jack and Jill also have submarines, and they want to get there and protect the gold, and keep it away from Evil Mister Fred. And Evil Mister Fred has propellers on the back of his submarine, but he put them on there and everything, and they're supposed to spin, but it never worked. So he had to drill holes in the side and put out oars. So his minions have to row the submarine underwater. Minions can hold their breath for about a month. There's Evil Mister Fred on the front. He's got a fishbowl over his head.

And Jack and Jill are not searching for gold, they're searching for Gepetto. Gepetto was swallowed by a big whale. So we need a big whale. There. There's Moby Richard. He likes to be called Moby Richard. And Gepetto is inside. He's floating around in his boat here. He's got a rowboat in there with Gepetto inside. And Jack and Jill are trying to rescue Gepetto. Well, Gepetto has it hard, too, because he's got his fake son with him. What was that guy's name? Pinoccio. Pinoccio is always goofing around. You never know what Pinoccio's going to do. And he's gotten this really long nose because he doesn't tell the truth. There's Pinoccio.



Gepetto and Pinoccio inside Moby Richard.

And Jack and Jill and all of their Kick-mes are in mini-submarines, floating around looking for Gepetto. So they're coming from this direction. Those are propellers. And they've got windows on them so they look like fish underwater. And this one has Jack inside, and this one has Jill inside, and the rest of them all have Kick-mes inside. Full of Kick-mes, so there are hundreds of them with Kick-mes in there, like that.


Jack, Jill, and Kick-mes in mini-subs.

And they went right over Ernie and the Titanic. They saw all the gold down there and they said, "Ooh, look at all the gold. How ya doing, Ernie? How's things going?" Ernie says, "Just fine, thanks. Have a nice day." And they took off.

Well, they went a little ways, and there's Evil Mister Fred. And Evil Mister Fred saw them, and he said, "Enemy straight ahead! Ram them, boys!" And all the minions start rowing as fast as they can. And the minions went crashing into the submarines. They'd hit all the submarines, break holes in them, and the submarines would sink to the bottom. And the Kick-mes said, "Woo-hoo!" And they'd go down there and get crushed. They like it when they get crushed.


Crushed Kick-Mes tethered to their subs.

So now, a Kick-me ordinarily looks kind of chubby, like this. But when you put him down twelve thousand feet, he ends up looking like that, because the pressure of the water squeezes him in all directions. Maybe he'd be really long, and look like that with two eyes sticking out. And he's happy because he just got crushed.

So there's a bunch of Kick-mes down there saying, "Yay, do it again!" And Jack and Jill said, "Oh, no, our submarines are all stuck at the bottom." And the Kick-mes are attached to the submarines by rubber cords. They're not smart enough to untie them, and they don't have hands anyway. And Jack and Jill

manage to escape Evil Mister Fred and his crushing blows by his submarine. And Evil Mister Fred said, "Yeahhh, I got rid of most of those guys. There's just that evil Jack and Jill left. Arrrghhh! I'll get them, though."

Now, Jack and Jill have to get all their Kick-mes up off of the bottom and rescue them before they can deal with Evil Mister Fred. Now, if you're Jack and Jill, how would you get them off of the bottom?

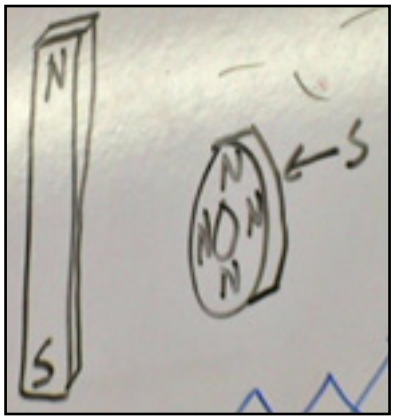
Imagination and Brainstorming Time

[Students make suggestions] (THERE ARE NO WRONG ANSWERS! Whatever they say, you should reply: "That's a good idea," "They might do that," etc. After brainstorming, proceed with the experiments, then finish the story.)

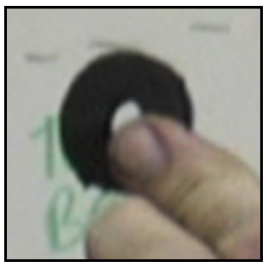
And we're going to leave this "To be continued . . ."

Experiment: "*Super Strong Magnets*"

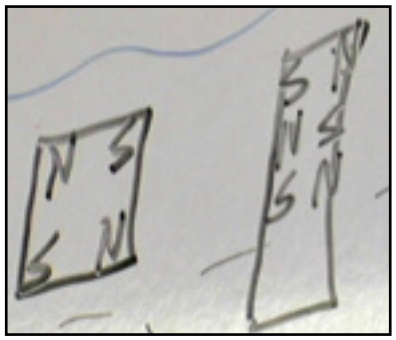
Sometimes magnets look like a bar, and there's a North on one end and a South on the other end. Sometimes they can look like a circle. Sometimes there's a North on one side and a South on the other side. You can make any kind of magnet you want. If you wanted to, you could make a magnet look like a square, with a North there and a South there, and a North there and a South there. If you wanted to, you could make it like a big bar with North, South, North, South, North, South -- you can make them any way you want.



Common shapes of magnets.


Doughnut magnet.

Today we're going to be using magnets that look like this *[circular shapes]*. They're North on one side and South on the other. They kind of look like doughnuts. Doughnut magnets. And they're not particularly strong, but we want to find some way to make them stronger than what they are.



Other types of magnets.

First, we need to see what you remember about magnets. This is a magnet that I took off of a horse. This one has a North on this part of it and a South on that one. And it's got a ball that's made out of something . . . *[Student: Metal!]* Is it made out of metal? It's not made out of bubble gum? *[Student: Iron!]* Iron. Okay, it's made out of irons. We want to find out what the ball's made out of. Somebody said it might be made out of iron. What if the ball was made out of cardboard? Would that stick? *[Students: No.]* No? Okay, let's try cardboard. And there you go, cardboard doesn't stick. *[Instructor tries various materials to see whether they stick to the magnet.]* What if it's made out of wood. Will wood stick? *[Students: No.]* You're right, wood doesn't stick. Will brass stick? It's metal. *[Students: No. Yes. Probably.]* Doesn't stick. Will aluminum stick? *[Students: No. Yes. Maybe.]* No. This one is stainless steel. There are two kinds. Will it stick or not stick? *[Students: No. Yes.]* Not stick. Now we've got two left, copper and steel. Will the copper stick? *[Students: No.]* Oh, you guys are good. Are you sure that's a magnet? Okay, let's try the steel and see if that sticks. *[Steel sticks.]*


Steel plate between ball and horseshoe magnet.

Well, you notice that the ball isn't attracted so strongly. The ball falls down more easily when the steel is in the way. The energy of this magnet is being absorbed by this steel plate, and it goes through the steel plate and it connects North to South. So it gets robbed, and the ball doesn't stick as tight. Well, we can use that to our advantage. At least, you guys can.

If you can get a North to be close to a South but not touching the South, something weird happens. Something strange happens.

So right now, *[holds up a doughnut magnet]* there are Norths on this side and Souths on that side, and they come together all around the outside edges and around the hole in the middle a little bit. And if you try to grab something with it, like a steel plate, you can see it wiggles the plate a little. You can put it right on the plate, and it's strong enough to lift the plate that way, just barely. But we want to find some way to make this really strong. And you guys are going to be using these kinds of magnets, and we'll give you stuff to try and see how strong it is.

Pulling the magnet to make the angle bracket pull on the scale.

But it helps if you have some way to guage whether it's stronger or weaker than before. And we have some weird-looking things with hooks on them. And there's a spring in the back. So you can pull on this and see if you're making something that's stronger. If you set this on the table, and you have somebody on the other side. . . *[to a student]* here, you be the other guy and hook your finger in that. Oh, I need one more thing. You need something for the magnet to grab. Turns out we've got a whole bunch of these pieces of steel. Steel brackets, right angle brackets. Or maybe wrong angle brackets. And you can hook a bracket onto the hook. Then, if you put a magnet on the bracket and pull, you can see that it pulls about -- these are in grams -- one little tiny line worth of grams, which is like maybe fifty grams if you're lucky, by itself.

We're going to give each group a scale, and a bracket, a bunch of magnets, and a bunch of other stuff. And then, you see if you can find some way to make the magnet stronger than it is. So pick one other person to work with, someone to be on the other side of you. And we'll start passing out stuff. *[Instructors pass out one scale and one bracket to each pair of students. Then they pass out one doughnut magnet to each group. Students put the magnet on the bracket.]* Try pulling on it and see if you can make the scale wiggle. *[Some students try to pull the bracket itself instead of pulling on the magnet.]* Use the magnet, not your hands.

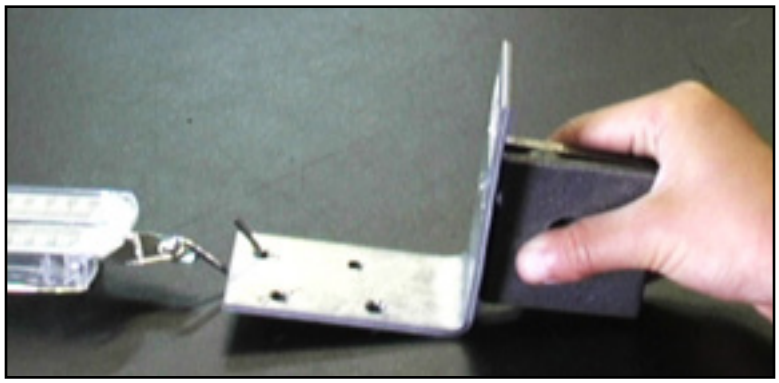
[After a couple of minutes, Instructor passes out a second doughnut magnet to each group.] We're giving you a second magnet. See if that helps out. Take turns. *[Instructor passes out two steel squares to each group, and students try to combine them with the magnets. One group figures out how to sandwich the doughnuts between the two squares to make them much stronger.]*

Reading the scale.

I'll give you a hint: Sandwiches are good. Sandwiches are your friend. *[Student: It doesn't stick.]* It doesn't stick? Oh, no. Try it a different way. It's okay to copy other people's ideas, that's the American way.

[After a couple of minutes, the Instructor picks up the magnets from the group that made the sandwich.] Everybody stop for a minute. We've just had a hacker hack into these guys' brains. And the hacker stole

their idea and published it on the internet for everybody to see. And what the hacker showed was, they put two magnets kitty-corner between two plates, but they stuck them on that way *[by the edge, instead of the flat surface]*. Now you've just had a vision into their brains. *[Other students try to make similar sandwiches.]* The record is two thousand. See if you can beat two thousand.



Round magnets sandwiched between steel squares, attached by the side edges to an angle brackert.

Attention, please. You've got two magnets there. Is it stronger if you put one magnet on top of the other magnet and test it like that? Is it stronger if you put the magnets with both North sides toward the plate? Is it stronger if both magnets have the North side on one side? Or is it stronger if there's a North and a South side by side? Try it all those ways and see what you find out.

[After another couple of minutes, Instructor calls for a stop.] You're going to keep the scale and the bracket, but we're going to take the magnets and the plates. *[Instructor collects magnets and plates.]*

Neodymium magnet.

Okay, now I want everybody to look at your hands. Look at your hands. Do you have any blood blisters? *[Students: No.]* Do you want to keep not having blood blisters? We're going to give you some magnets that come out of computer hard drives. They're neodymium magnets. If you get your finger between the magnet and a piece of steel, you'll get a blood blister. You get extra points if you get a blood blister, but they hurt a lot. *[Student: What are points?]* Points? It's what you get when you hurt yourself. If you do a good blood blister and you do a good ooh-aah-ooh-aah dance, you can get some extra points for the dance, too.

When you're putting the magnet on the bracket, it's best to slide it on, like that. Leave a little hanging over the edges. And then you're going to pull on the magnet, not on the bracket, and see if this magnet is any stronger than the ones that you had. And to get it off, good luck. *[Instructor passes out one magnet to each group, giving the thicker magnets to the older students.]*

Pulling 5,000 grams.

[Student: So you could get blood blisters?] Oh, yeah. *[Student: What area?]* Well, you could get them on your head if you stuck your head in there, but I don't recommend that.

[With the neodymium magnets, students are able to pull five thousand grams, the max on the scale.]

[After a few minutes, Instructor calls time and collects all of the scales, brackets, and magnets. Then Instructor brings out a weight.] Here is a twenty-five pound weight. And here's a bathroom scale. We'll put the weight on the bathroom scale. There. Okay, we're going to try this. This is an old-fashioned magnet. It's not as strong as the new guys. But somebody put them together in rows. There's one, two, three, four rows of magnets. It's made out of aluminum-nickel-iron magnets, and it was used in a machine shop to pick up pieces off the floor. Let's see if it will lift a twenty-five pound weight. *[Places magnet on top of weight, which is sitting on the scale, then begins to pull upward on it.]*

4-bar magnet.

Picking up a 25-lb weight with a magnet.

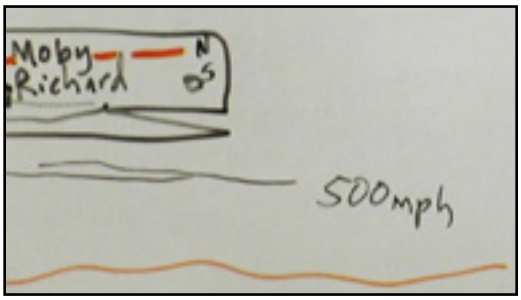
There's twenty pounds *[reading the scale]*, fifteen, ten, five, zero -- aha! It picks up a twenty-five pound weight. Now, you can pull it off if you tilt it one way, or if you tilt it another way. But if you pull straight up, it'll lift about seventy-five pounds lifting straight up. So it's not coming off of there anytime soon. If you want to get this kind of magnet off by sliding, you can slide it off. Now, if you have a magnetic head, and you weigh less than seventy-five pounds, I could pick you up. *[Places the magnet on various students' heads.]* Aww, her head's not magnetic. Aw, so sad. You guys have un-magnetic heads.

End of Story

**** DO NOT * present this part of the lesson until after the experiments!***

Well, you remember Pinoccio? He's got that long nose. Did you know that his nose was not made out of wood? His nose was made out of steel, stretchy steel. It turns out, Moby Dick's head is a giant magnet. Moby Richard, sorry. That's why Pinoccio's nose was getting long. They thought it was because he told lies, but no, it was because Moby Richard was getting closer and stretching his nose out.

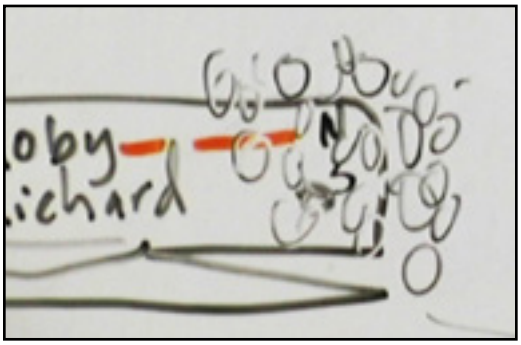
And Jack and Jill were trying to rescue all the submarines that Evil Mister Fred had sunk with his submarine castle and get their Kick-mes back up to the top again. And Jill, she can talk underwater. She goes *[makes a high-pitched, garbled, warbling sound]*. And to us it just sounds like *[high-pitched, garbled, warbling sound]*, but what it means is, "Uh, Moby Richard, could you please come over here? We need your help a little bit. That magnetic head of yours would be very handy." And Moby Richard, of course, heard that from a hundred miles away, and he zoomed right over. And the closer he got, the faster he went. And Moby Richard said, "Oh, no. This is bad. Something's magnetic here."



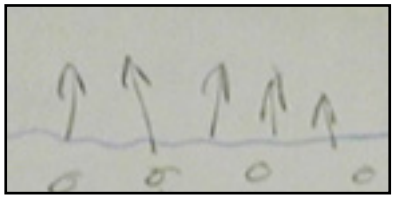
Moby Richard's going 500 mph.

What's the Titanic made out of? *[Student: Steel.]* Steel. So as Moby Richard approached the Titanic, his speed kept getting higher and higher and higher, until now he's going five hundred miles an hour underwater.

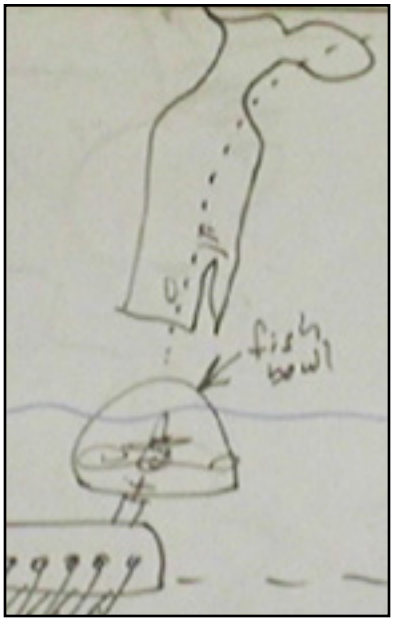
Now, Moby Richard weighs, oh, maybe a hundred tons. A hundred tons, five hundred miles an hour, hits the side of the Titanic. And ka-wham!! The Titanic just went ka-boooom!!! And Moby Richard went shooting right through. Luckily, it slowed him down a lot. And Ernie, the unicorn ghost, said, "What are you doing? You just wrecked my ship! Arrrghhh!" But Moby Richard couldn't stop, going too fast, and now bong, bong, bong, bong, bong, bong -- all the submarines with the Kick-mes stuck to his head. So now Moby Richard's got Kick-mes and submarines stuck all over his head. And Jack and Jill said, "Yay, Moby Richard! Take them to the top!"



Kick-Me submarines stuck on Moby's head.


Moby spit the Kick-Mes out into the air.

So Moby Richard zoomed back up to the top, and luckily he can turn off his magnet, and spit out all the Kick-mes up into the air. And Pinoccio and Gepetto, of course, are saying, "What's going on?" They can't see what's going on. All they felt was this incredible acceleration. And Moby Richard shot up into the air. You ever see a whale shoot up into the air? Well, this one did. He shot way up into the air and released all the Kick-mes, who thought this was great fun.



Moby lands on Evil Mister Fred.

And sooner or later, Moby Richard has to land again. He's up orbiting the earth, and now he's coming back down. And Moby Richard accidentally hit Evil Mister Fred. And Evil Mister Fred got squished inside his fishbowl, and he got stuck to the bottom of the ocean. If you swim down there, you'll find a big fishbowl there, with Evil Mister Fred inside. And they all lived happily ever after, except Evil Mister Fred.


Evil Mister Fred stuck in his fishbowl on the bottom.

[Student: What about Ernie?] I think Ernie managed to pick up all the gold and pile it back up again. I don't know about the Titanic. If you get his by a whale at five hundred miles an hour, it's probably a big mess. He probably moved it to a different shipwreck. *[Student: What about Pinoccio?]* Pinoccio? Should we leave him inside Moby Richard, or should we have him spit out in midair orbiting the earth?

End of Lesson

If you have questions about this lesson, please ask them through the online Teacher Support Forum on our web site.