



Teacher's Guide for:
Bolos & Trebuchets

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.

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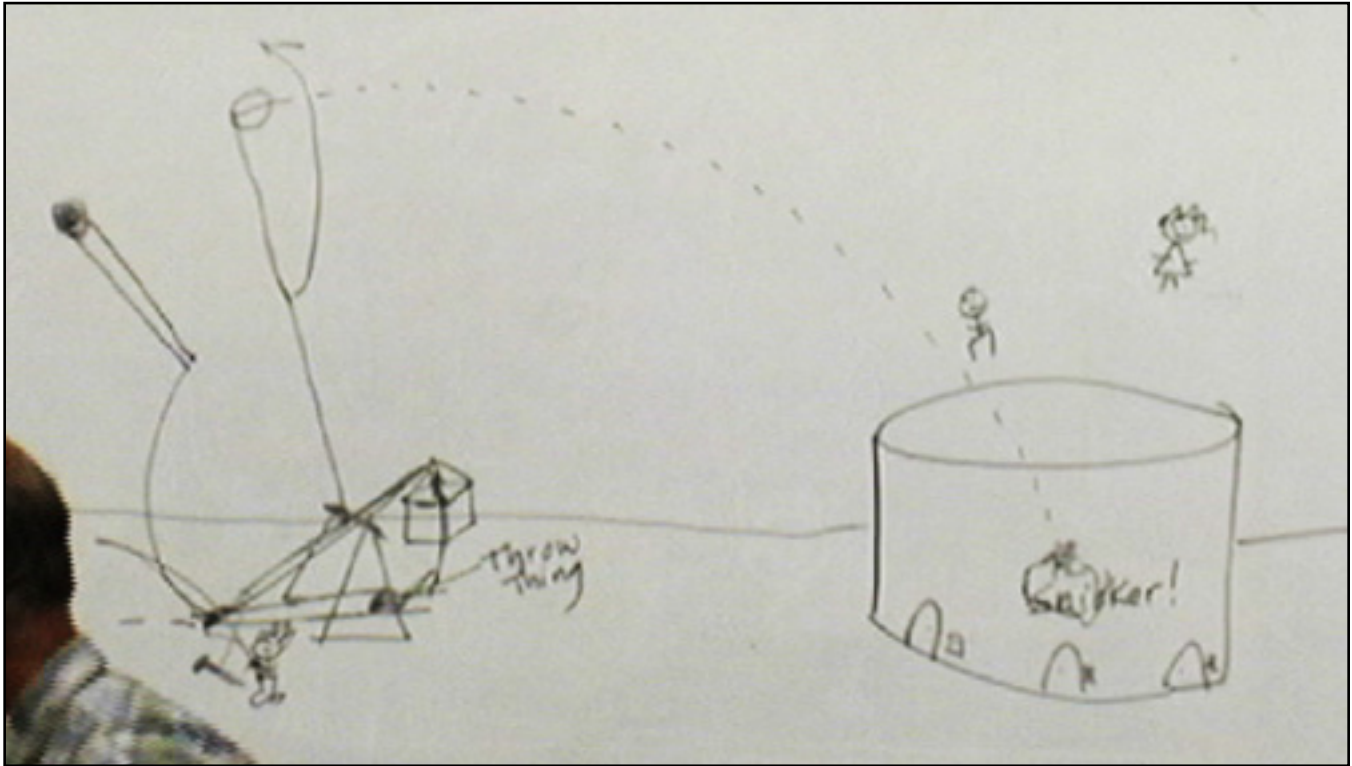
Title Page of Video

Bolos & Trebuchets
A Rock-it Science Lesson
Filmed June, 2011

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Intro Quick Recap:



- In the old days, if you wanted to attack a castle and couldn't get inside it, you would build a trebuchet.
- It's made of a big frame about one hundred feet tall with some telephone poles on it.
- There's an arm that sticks out, with a bucket on it filled with heavy weight.
- On the other end is a rope, and you put the rope under the arm.
- You loop the rope and put the end of it on a nail sticking out with a loop.
- You put the thing you want to throw in a basket on the rope.
- The arm is tied down to a stake in the ground. When you want to fire it, you cut it with your pocket knife.
- You could throw a boulder filled with helium and gun powder.
- When you release it, the arm swings up into the air as the weight in the box goes down. The rope swings way out on the end of the arm, with the boulder on it.
- When the arm gets into the top position, the rope unfolds and the boulder shoots out, right into the castle. And it blows up.
- And the people breathe in the helium and start floating away.

Experiment Quick Recap: "Bolos"

- Show students a sling with a leather pouch. Demonstrate how to swing it around and release the projectile.
- In olden days, guys could get really good at this, even swinging the sling overhead.
- They could throw a football-sized rock two hundred yards and hit someone between the eyes and kill him.
- In an earlier experiment, we tried using slings with rubber balls in the pouch. But the students were flinging them in all directions, and we ended up losing all the balls.
- Now we use a modified version of a bolo. We use a tennis ball with a rope attached to it.
- Students only swing the rope in a forward-to-back circle, not overhead. This way, when they release it, it will only end up going either in front or in back of them, not to the side.
- The experiment is done outdoors.
- Instructor demonstrates how to swing the rope and release it. Explains that the ball will go in a different direction depending on when you let go.
- Tell students not to try to swing the rope hard or fast. Start out easy, until they get the hang of it.
- Taller students can hold the rope by the end; shorter students may need to hold the rope further from the end to keep it from hitting the ground when they swing it.
- Students pick a partner and line up in two rows, facing their partners. Rows are about twenty feet apart.
- Students in one row receive a bolo and fling it toward their partner. Then the partner retrieves it and flings it back. Students continue taking turns this way for several minutes.



Sling: Whatever you want to throw goes in the pouch.



Modified sling: Tennis ball on a rope.

Demo Quick Recap: "Trebuchets"

- *Students do NOT operate these trebuchets -- only the Instructors do.*
- Students are cautioned to stand to either side of the trebuchet, not in front or behind it.
- Instructor demonstrates how the small trebuchet works and launches a small water balloon.
- After seeing how far the balloon flies, students may stand in that area and try to catch the balloons as they land.
- Instructor demonstrates three or four launches of the small trebuchet.
- Then students move to the large trebuchet.
- Students are cautioned to stand about six feet away from the trebuchet on either side. No one is allowed to stand in front or behind it.
- Students are NOT permitted to stand in the target area to catch the projectiles from the large trebuchet.
- Instructor explains that this device is not adjustable. The distance the projectile travels is determined by the weight of the projectile.
- Instructor starts out by launching a small orange. It travels only a short distance.
- This is followed by a medium-size orange, then a large orange.
- Then two oranges at once, which travel a little farther than the single orange.
- The last projectile is a water balloon, which is considerably larger than the oranges and travels much farther.
- Before returning to the classroom, students help pick up smashed oranges and water balloons.



Instructor sets up small trebuchet.



Instructor sets up large trebuchet while students watch from a safe distance.

Equipment List: "Bolos & Trebuchets"

Items needed for Instructor:

- Small trebuchet
- Large trebuchet
- Rolling platform for large trebuchet
- Sling with leather pouch
- Balloons, 11" (holding about 1 cup of water), 5-6 ea.
- Balloons, 11" (holding about 4 cups of water), 2-3 ea.
- Fruit, round, of 3-4 different sizes, such as oranges, grapefruit, melons. At least 1 of each size.
- Bucket, 5-gal plastic, for water balloons
- Crate, plastic, for fruit
- Cart, rolling, to transport fruit and balloons

Prep Work:

- Build bolos:
 - Tennis balls, 1 per 2 students
 - Rope, approx. 3 ft ea.
 - Tape, duct, 1/2" (to attach ropes to tennis balls)
- Inspect trebuchets to make sure all parts are securely assembled.
- Fill small and large water balloons.
- Buy oranges (you can also use grapefruit, melons, etc.)

Items needed for Students:

Consumables (per student):

- None

Other (per group of 2 students):

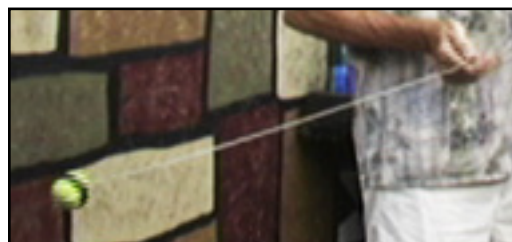
- Bolo (tennis ball with 3-foot rope attached)



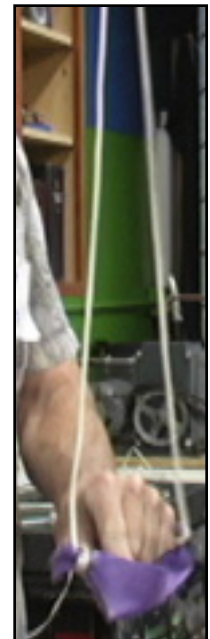
Small trebuchet.



Water balloons.



Tennis ball bolo.



Sling with pouch.

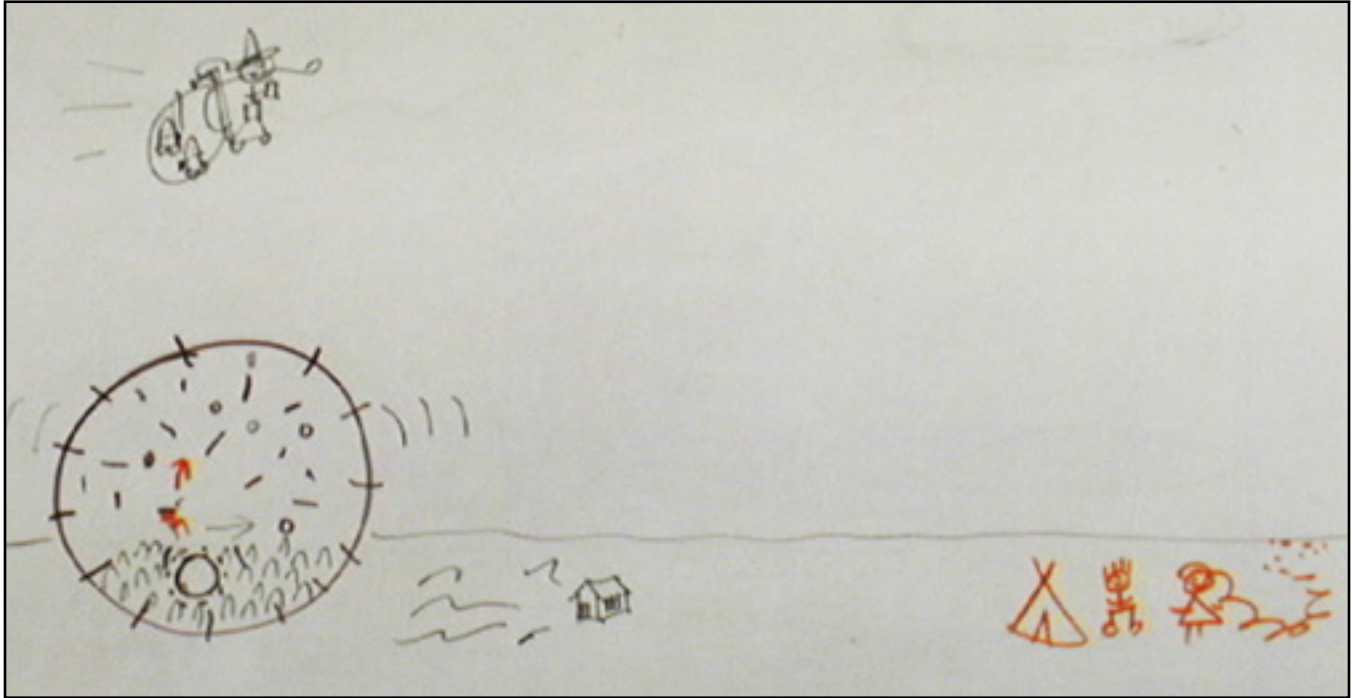
Equipment List, cont.: "Bolos & Trebuchets"



Large trebuchet.

This large trebuchet was specially constructed and modified for Rock-it Science. The smaller one (see previous page) was built from a kit. On the internet you can find many sources for trebuchet kits as well as plans for building your own. The lesson presented with the large trebuchet can be conveyed just as effectively using a smaller trebuchet and smaller projectiles.

Story Recap: "Evil Mister Fred's Invincible Machine"



Part 1:

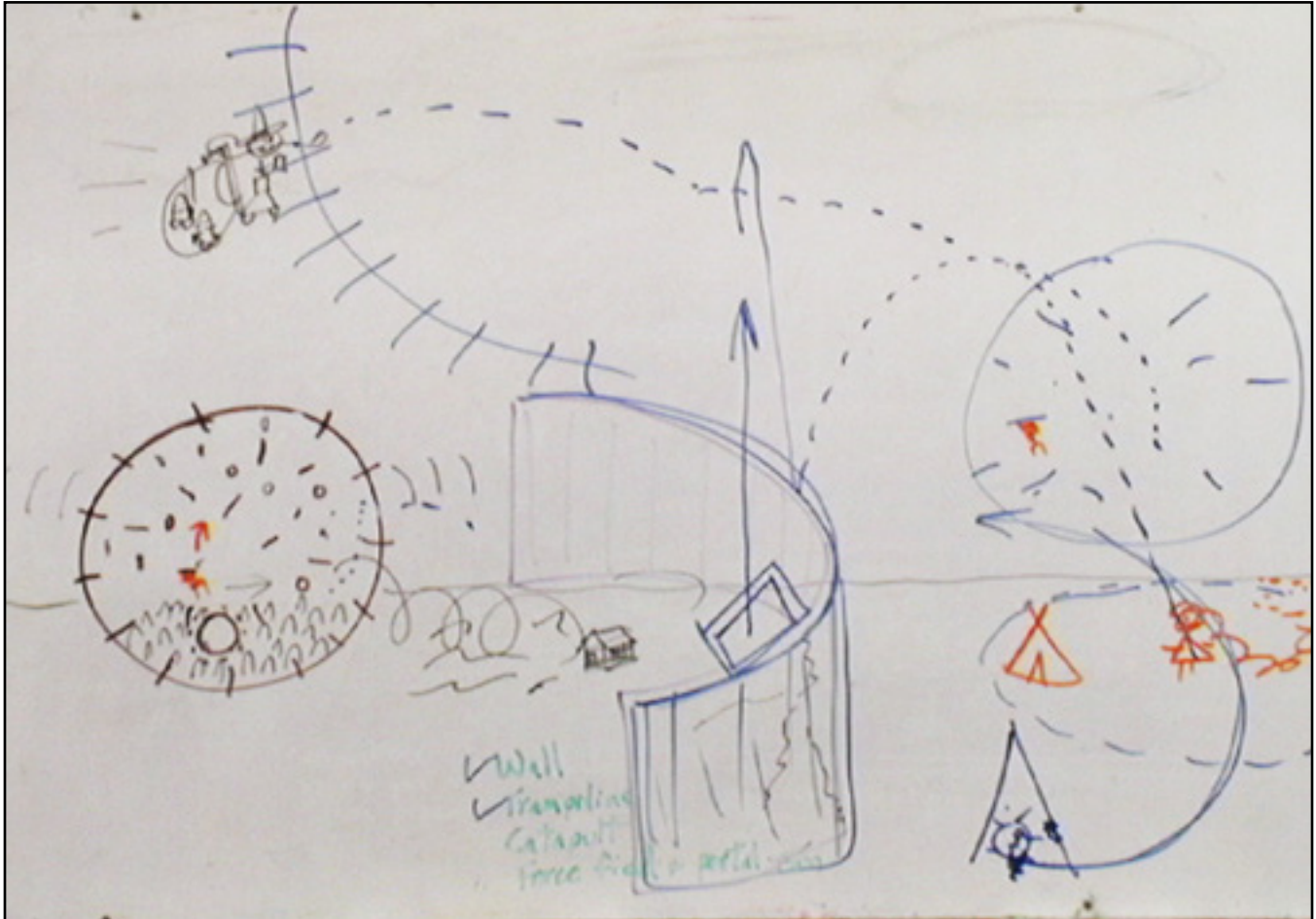
- Evil Mister Fred wants to invent an invincible machine so he can take over the world.
- He builds a huge steel ball with spikes all over it, and he puts a door on it and a couple of windows.
- The ball could run over anything and destroy anything in its path. But he needs something to make it run.
- He takes thousands of minions and stuffs them inside and closes the door.
- Inside the ball, the minions can only hear elevator music and Evil Mister Fred's voice from his cell phone.
- Evil Mister Fred starts flying around on his vacuum cleaner with a couple of spare minions in the bag in case he needs them.
- Using his cell phone, Evil Mister Fred tells the minions in the ball to all start walking in the same direction. So of course, they all start walking in different directions, so the ball doesn't go anywhere.
- After some more practice, the minions manage to walk in the same direction and the ball starts to roll.
- It starts crushing everything in its path -- rocks, houses, fields, peasants -- and everybody's screaming. So the people call Jack and Jill for help.
- Jack and Jill are living in a tepee, and they see the cloud of dust and hear the screaming and see the giant ball rolling over everything.

Story Recap: “*Evil Mister Fred's Invincible Machine*”

Part 1 (cont.):

- Jill tells Jack to jump onto the giant ball and examine it to see if it has any weak points.
 - Jack doesn't want to do it because he could get killed, but Jill tells him to go anyway.
 - So Jack climbs onto the ball and hangs onto one of the spikes while the ball keeps rolling.
 - Evil Mister Fred spots Jack and tells his minions to roll in that direction in order to crush Jack.
 - But the minions mistakenly start rolling the other way, so Jack has a few extra seconds before the ball will drag him over the top, down the other side, and crush him completely flat.
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Story Recap (cont.):



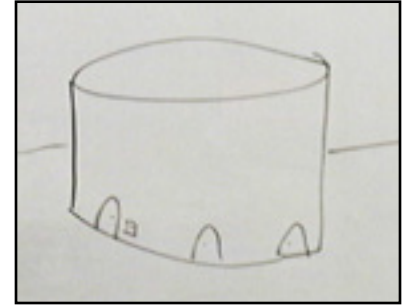
Ending:

- Jill called the Acme Store of Everything and ordered a giant wall to place around the ball.
- Evil Mister Fred decides to roll the ball forward to destroy the wall, instead of rolling sideways to crush Jack -- he'll try to crush Jack later.
- The ball rolled over a house and into the wall, and the wall started to crack.
- Jill ordered a force field, a portal gun, and a trampoline. She put the trampoline in front of the wall and the force field right behind it.
- The minions ran faster toward the wall and the ball hit the trampoline. It bounced straight up into the air, came down on the top of the force field, bounced again, and started to come down on the other side, right above Jill.
- Jill uses the portal gun to open a portal to another dimension where there's a trebuchet that's big enough to hold the giant ball. Jack and Jill and the ball all pass through the portal.
- Just as the ball reaches the trebuchet, Jack jumps off, and the trebuchet launches the ball back through the portal. The ball comes flying back into this dimension and lands on Evil Mister Fred.

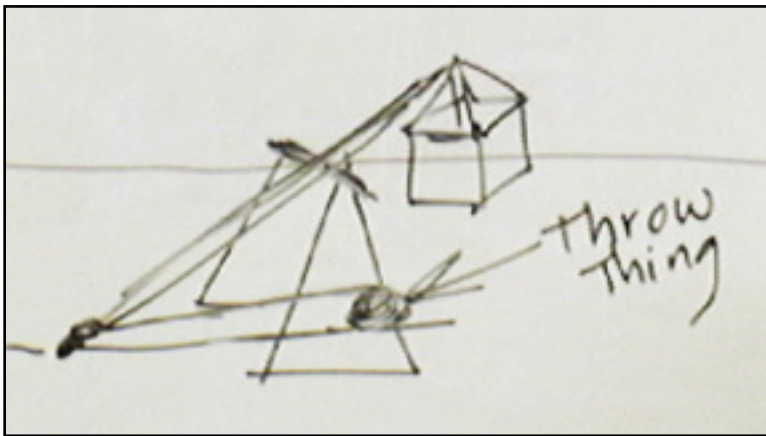
Transcript: Intro

In the old days, if somebody was in a castle, and you didn't want them to be in a castle—you wanted to have them come out so that you could stick 'em with swords and enslave them and stuff, and they wouldn't open the door for you, how rude is that?

So you go ring the doorbell and nobody answers the door. And you go ring another doorbell. Nobody answers the door. You keep going all the way around ringing doorbells and they're all sitting inside going *[laughs]*, "They can't get us."



Castle.



Trebuchet with rope underneath and the "throw thing."

So you're on the outside and you build yourself a nice trebuchet. You make a big frame a hundred feet tall, put some telephone poles on it. And these guys act a little weird. They have an arm that sticks out and there's a bucket on the end of the arm full of something heavy. So you put a big heavy bucket out here. You can fill it full of rocks or whatever you've got laying around. There's a box that's heavy.

On the other end you don't put what you're going to throw — you put a rope on the other end. And you don't dangle the rope out this way, which would seemingly make sense. You put the rope under it. And then you curl the rope back and you put the end on a nail sticking out with a loop. And then, the thing you want to throw you put in a basket right there. That's the "throw thing."

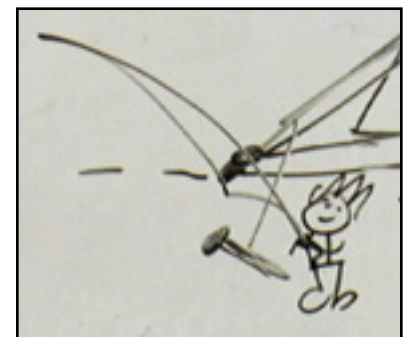
Okay. So now, there's all those people in the castle snickering at you. Because you can't get in. And now you've built this crazy contraption.

The arm is being held down by maybe a rope tied to a stake in the ground. And you're out there with your pocket knife and it's your job to cut the rope.

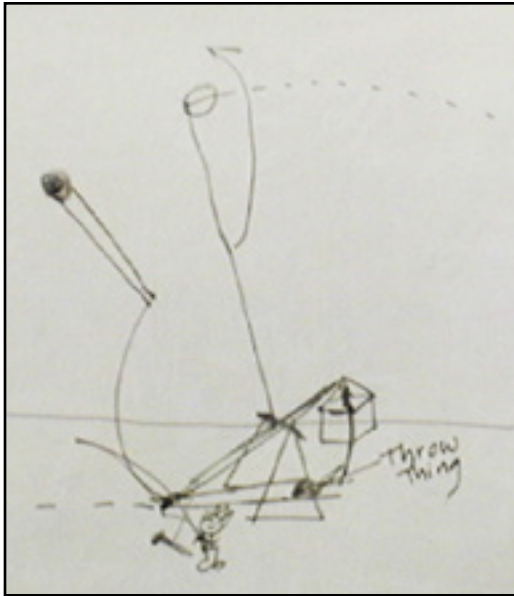
When they say "Fire", you use your pocket knife and cut the rope! So, they say "Ready. Get set." Oh, wait a minute, we have to decide what they're going to throw. If you're the bad guy and you're going to throw something over a castle wall to make them stop snickering, what would you throw?

[Student: You could throw a big boulder full of helium and gun powder.]

Okay, a big boulder full of helium and gun powder. So they say "Five, four, three, two, one." You cut the rope, the arm swings up into the air,



Pocket knife.



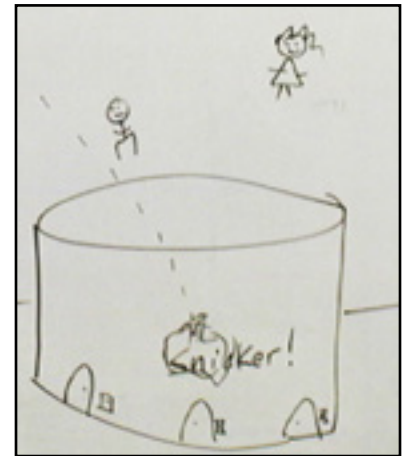
Arm swings up and releases boulder.

the weight goes down. The rope swings way out on the end of the arm with the big boulder full of helium and gun powder. And then when it gets right up to the top position, the rope unfolds and the projectile shoots out. Right into the castle.

[Student: And it blows up!]

And it blows up. Gun powder, helium, everything. And the helium is breathed in by all the people in the castle and they start floating away. And they talk real funny.

So today we're going to try to find out how these slinky kind of things work. But first we need a crazy story.



People floating.

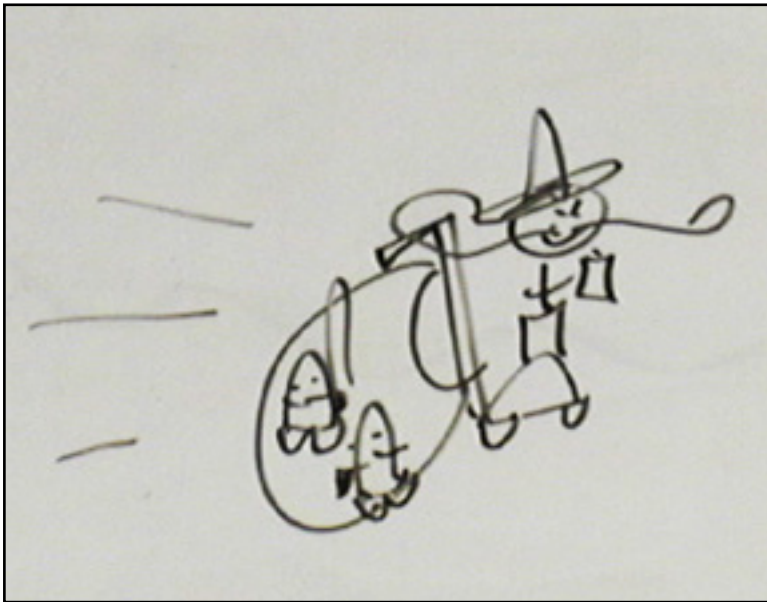
Story: "Evil Mister Fred's Invincible Machine"

Let's see — Evil Mr. Fred has decided that his minions don't make a very good army. But he figures he has the world's best brain and he can invent a machine that is invincible and he can take over the world. So the Evil Mr. Fred got together a bunch of parts and he put together a huge ball. And he put spikes on it. And he put a door on it. And he made it out of strong steel. There's a door. And a couple of windows I guess, so you can see out. And he said, "There you go!" This is an invincible machine. I can run over cities and anything with this and nothing can stand in its path."

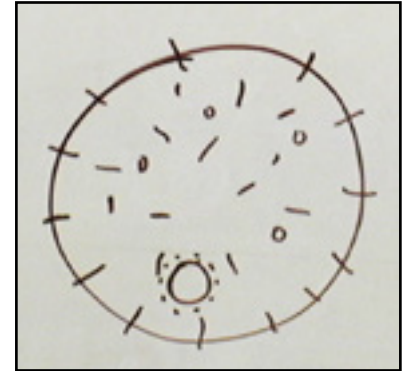
And the minions said, "But boss, it's a ball. How does it go?" And Evil Mr. Fred said "Well, we could use hamsters, but I have something better." And the minions said, "Oooh, what?" And Evil Mr. Fred said, "Minions!" And the minions said "No!!!" And Evil Mr. Fred wouldn't listen to them, stuffed them all inside and closed the door. So now, there's about a thousand minions inside.

The minions are all saying, "Let me out! Let me out!" And Evil Mr. Fred — let's put him somewhere. He's got to be watching from some distance. Ahh, let's put him on his vacuum cleaner. Yeah, he flies around on a vacuum cleaner.

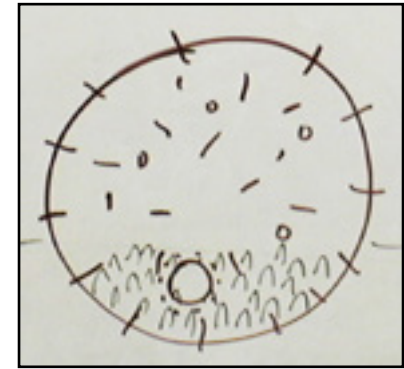
And he always keeps some spare minions in the bag. Because you never know when you're going to need a minion. They're the lucky ones. The rest of them are all inside the big ball. There. He's flying around. And he's got a cell phone. And all the minions inside here have to listen to elevator music and Evil Mr. Fred's voice.



Evil Mister Fred flying on his vacuum cleaner with minions inside.



The invincible machine.



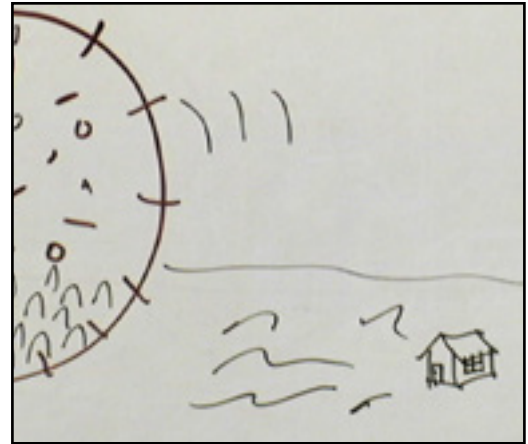
Minions inside.

And Evil Mr. Fred says, "All right, minions. Everybody start walking the same direction." And the minions say, "Okay boss." And some walk that way, some walk this way. Some walk that way. Some walk that way. And the ball just kind of rattles and stuff and doesn't move. And Evil Mr. Fred says, "Nooo!!! You morons. Go the same waaayyy!" And they say, "Okay." And miraculously, they start walking the same direction. And the ball starts to roll. And Evil Mr. Fred said "Yes!! I knew it would work. The Invincible Machine. This is perfect." And the ball is crushing everything in its

path. Rocks, houses, fields, peasants — running, screaming. And everybody says, “Nooo!! Evil Mr. Fred has an invincible crushing machine.” And they call Jack and Jill for their rescue.

And Jack and Jill just happen to be living there in a teepee. They're trying to live off the land. And they hear all the commotion and the rumbling. They see a big cloud of dust. Everybody's screaming. They hear crushing of beings as this thing rolls over everything. And they say, “Uh, oh. We've got a problem. Look at that giant thing coming towards us.”

And Jill says, “Jack, we've got to find out if it has any weak points. We need to investigate how that thing was put together



The ball crushes everything in its path.

and if there's any way to stop it.” And she says, “Jack, you're the man. You're tough. You're fast. You're smart. Run over there, climb on that thing and find out where it's weak.”

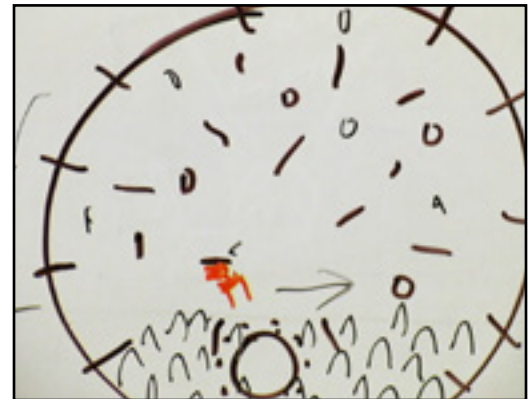


Jack and Jill and their teepee

And Jack says, “Climb on that??!! I could die!” And Jill says, “Yeah, but it'll be a good cause. You'll be a hero.” And Jack said, “I don't want to be a hero.” And Jill said, “Well, just go.”

So Jack ran over there. And he's climbing on this thing. And it's rolling. So here's Jack hanging on to one of the spikes for dear life. And he's yelling at Jill as this thing was rolling by. And Evil Mr. Fred says, “Now that was a nice touch. Minions! Everybody turn to the right. And roll that way.”

Well, Jack is on the right side. Of course, the minions turn to the left and start rolling the other way. And now Jack has this short window of opportunity. He's going uphill now. The ball is eventually going to drag him clear over the top, down the other side and crush Jack as thick as a piece of paper. If you were Jill, or Jack, what would you do?



Jack hanging onto the ball.

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.)

We'll leave this “To be Continued . . .”

Experiment: "Bolos"

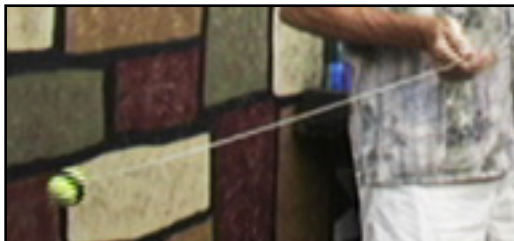
Now, they used to have in the old days, something called a sling. It didn't look exactly like this. It had — oh, I might have one of the old-fashioned slings laying here. Yeah. They had slings like this. Looks like a balloon. But it's not. It's a piece of purple leather. Because I got it cheap. And there's a loop in one end, and you'd put the loop on one of your fingers so you didn't lose it, and you'd hold the knot on the other end. And whatever you were gonna sling — you'd put in the pouch. And you'd swing it. You could swing it this way. And whatever's in there would go round and round and round. And then if you'd go like that and let go, it'll fly out of the pouch and hit whatever you're supposed to be aiming at.

The guys that got good at it would swing it over their head like this. And then they'd be running forward and throw their body forward and launch it that way. And those guys could throw a rock shaped like a football about two hundred yards. And they could hit a guy right between the eyes with a rock and kill him with this at two hundred yards. And those guys could also do one with their right hand -- if their right hand got damaged, they could do the same thing with their left hand. They practiced this most of their lives and learned how to kill people with football-shaped rocks.



Sling with pouch.

Well, I gave these once to a group of kids and I gave them like rubber balls. I said, "Here, go throw these around." Well, imagine this. Thirty kids all out in the field swinging these all over the place. The ball could go anywhere. And it could go a long ways. And we lost all the balls. They went up on roofs, down in creeks, lost in the grass — everywhere except where we wanted them. So I decided, well, let's make it a little easier for them to throw. Instead of having the pouchy business, we just put a ball on a string. And now you can swing it like this. So it's only going to land either out there somewhere or back there somewhere or it might go straight up and land on your head. Not much chance it's going to go that way or that way. So you're swinging it, and then you have to decide when to let go. And if you let go at just the right time, it'll shoot out there somewhere. And it can go a long ways. I'm not going to do it because it'll get lost in the boxes.



Swinging a tennis ball on a rope.

We're going to go outside, and probably the solution would be to make a line and throw them, and then run out there to get them and come back while other people are swinging theirs around to throw theirs. And so, while you're running, you come back and whack! -- right in the forehead with a tennis ball. Well, we'll have to figure out someway to do this so you don't get too many tennis balls smacked into your face. Oh, I have an idea. We'll make two lines — one line can try to throw it to the people on the other line, and then they don't have to run and get smacked. The other people can go get it and throw it back. So choose someone to be your victim. And they'll be the one that you throw it to.

And you don't have to hold the string by the end because if you're my height, and you swing it this way that's fine. But if you're not my height [*bends knees to make himself shorter*], and you swing this way, it does that [*ball hits the ground instead of swinging in an arc*]. So hold it wherever's comfortable so it doesn't go smacky, smacky on the ground. Okay, let's go out into the parking lot. [*Everyone goes outside.*]

Everybody get someplace where you're not directly in front of me or behind me. Because that makes sense. To throw this you don't have to throw hard. You don't have to throw fast. You can just be standing there spinning it like this [*swings ball on rope*]. Until you get the feel of it. And then at some point, you let go [*releases rope*]. And it goes in the air. [*Students run to retrieve the ball.*] Bring it back. When you get used to the idea of just doing it very gently, you can start throwing it further after that. But if you try to throw it hard first off, it usually doesn't go where you want it to go. Once you get the hang of it — you do it like five or six times at least, just gently to see how it goes — then you can start giving it a little more power and throw it high [*swings ball faster and releases it*]. Now, you're going to be throwing it to a partner. So there's going to be one group and then there's going to be another group, and you're going to throw it to your partner.

[*Students line up in two rows about twenty feet apart, facing each other. Instructor gives balls to students in one row only. They swing them and release them toward their partners in the other row.*]

[*After students practice with their bolos for several minutes, Instructor collects the bolos and brings students to the small trebuchet.*]



Students swing ball on rope and release it toward their partner.

Demo: "Trebuchets"

This is a trebuchet. You'll notice it has a weighted box on one end. This goes down, and then it gets released. If you're standing too close to it, it's going to hit you in the head. So stand back.

[Instructor loads a small water balloon in the trebuchet's pouch and launches it to see how far it flies. Then students move far enough away to try to catch the rest of the balloons when they come down. Instructor fires several small water balloons, then moves to the larger trebuchet.]

[Students stand at least 6 feet away on either side of the large trebuchet.] For watching this one, you need to either be on this side about this far away *[about six feet]* or that side that far away. No, you don't catch these.

This one you can't adjust things very easily. You have to adjust the weight that you're throwing. We're going to start off with small things and go to bigger things to see what the distance is. We'll start off with a small orange and see how that flies. And then we'll work our way up to bigger oranges and finally to water balloons.

[Instructor sets the trebuchet, places a small orange in the pouch, and launches it. Students are NOT allowed to stand in front of the big trebuchet or try to catch the projectiles. Instructor leaves them where they land. After the small orange, the Instructor launches a medium orange, then a large one. The larger the orange, the farther it goes. Then Instructor puts two oranges in the pouch and launches them. They go farther than the single orange. Then the Instructor launches a water balloon, which is larger than the oranges. It goes the farthest. Before going back inside the classroom, students help pick up the smashed oranges and water balloons.]



Instructor puts water balloon in small trebuchet.



The smaller fruit doesn't fly very far from the big trebuchet.

End of Story

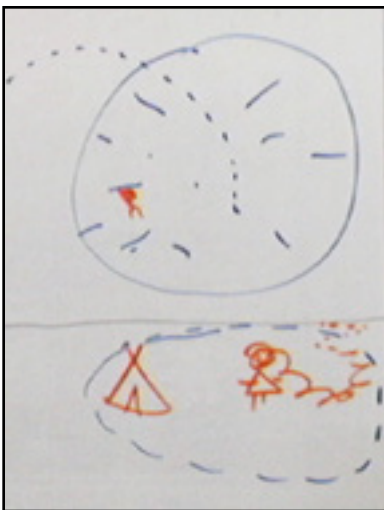
*** DO NOT * present this part of the lesson until after the experiments!**

So there's Jill. She's the one that told Jack to go climb on the Death Machine. And Jack, being a fool, climbed on top of it. And now Jack's gonna get squished. And Jill says, "I've gotta do something." And she called the Acme Store of Everything and ordered a wall. So they put a big wall around it. Giant wall like that. And the wall was directly in front of it, all made out of nice bricks.

And Evil Mr. Fred said, "Arghh, I gotta crush that wall. That looks like so much fun! But if I keep rolling sideways to crush Jack, I'll miss the wall." So he says, "Never fear. We'll crush Jack later."

So he says, "Minions, roll frontwards." And to his surprise, they did. And it went broom, broom, broom -- squished the house and hit the wall. And the wall started to crack. And Jill said, "Uh, oh, I need a force field and a portal gun."

So she put a force field around the wall to protect it. What does a portal gun do? *[Student: It makes a portal. So you shoot a portal right where the ball's about to roll into, and it goes through the portal and you shoot the portal somewhere else.]* Ohhh, I can transport it somewhere else. Ooooh, we'll save that part. And, just to make sure, Jill put a trampoline in front of the wall. So now she's got a trampoline in front of the wall. She's got a force field behind the wall. And, the portal gun we're gonna wait on.



The ball is about to land on Jill.

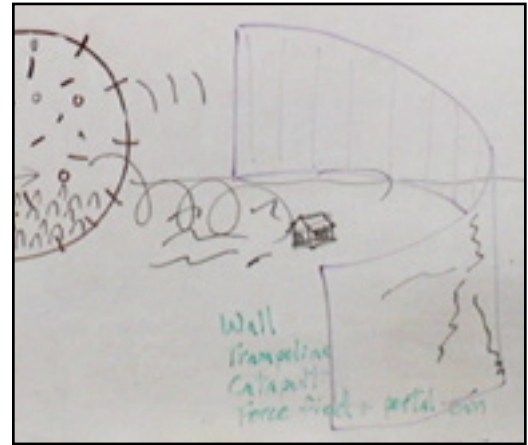
And Evil Mr. Fred says, "Yeah, can't stop me with that stuff. Not enough power there."

And he says, "Minions, go!"

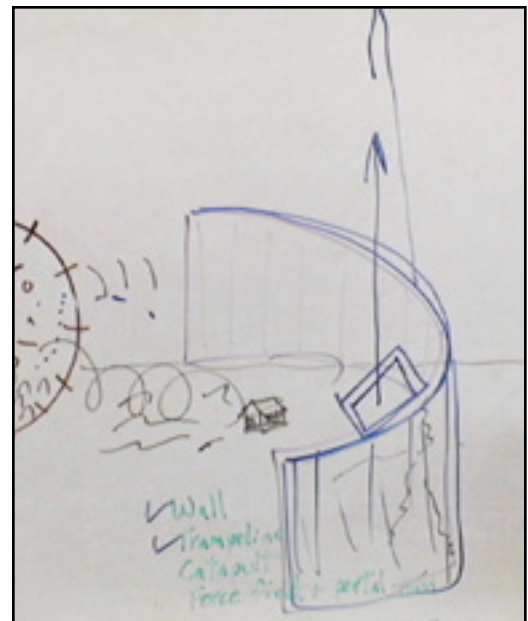
And all the minions said,

"Yayyy!" And they started running up the wall. And this thing runs in there, hits the trampoline, bounces straight up in the air, and comes back down, boink, hits the force field -- which wasn't intended for it to go that way -- and bounces, and now it's going to land right on top of Jill.

And Jill says, "Noooooo!" She sees there's a big shadow around herself as this thing is coming down on her. And Jack is hanging on to one of these spikes for dear life. And Jill says, "Ahh, now we need a tram-



The machine puts a big crack in Jill's wall.



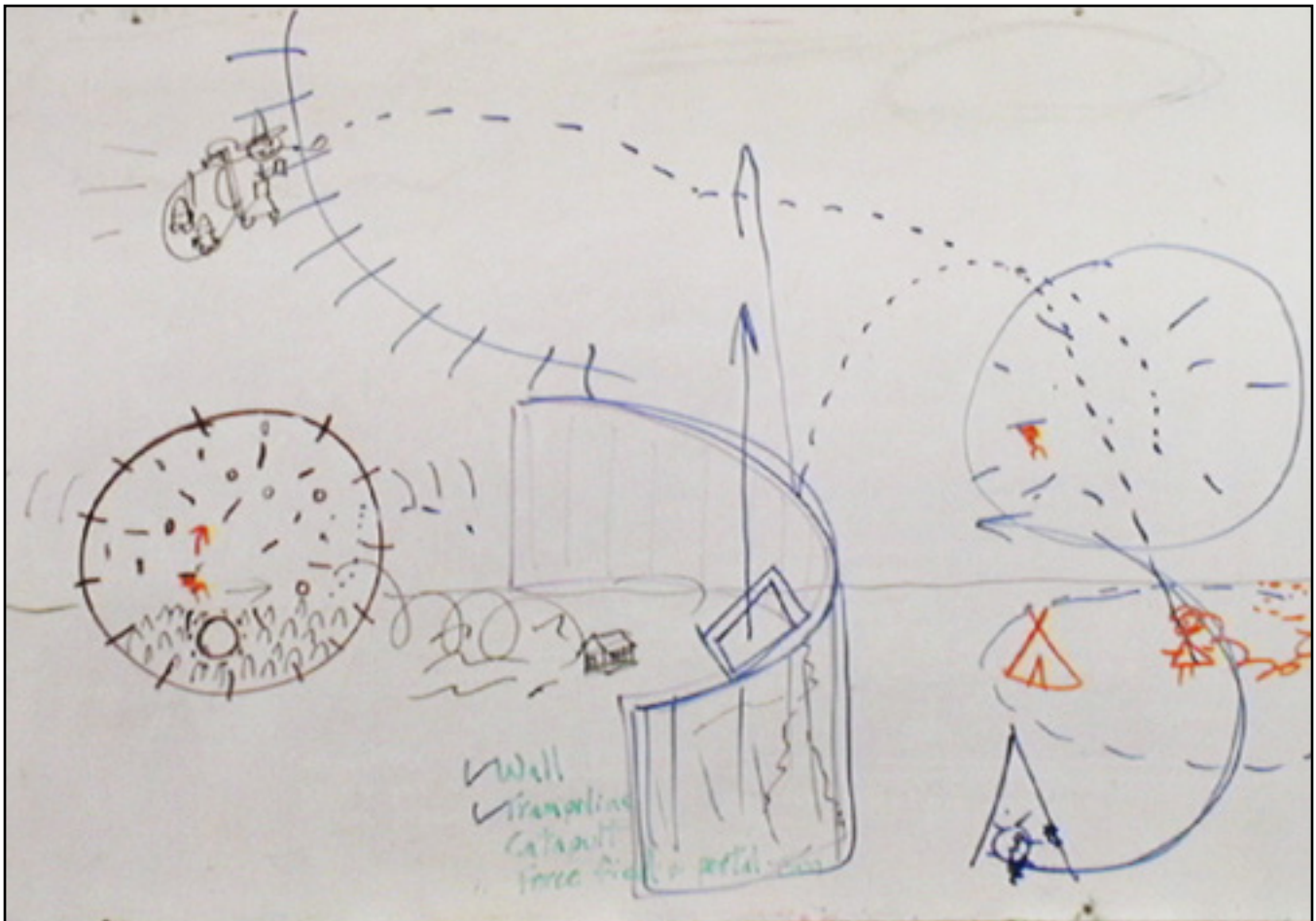
The ball bounces off the trampoline, then bounces off the top of the force field.

poline really fast 'cause I'm gonna get crushed." Not a trampoline. A trebuchet. She needs a trebuchet.

So she has the giant ball go through the portal with her and Jack, and now, in another space-time continuum place, there's this huge trebuchet and the ball is that big in it, with Jack hanging on. And Jill directly below it. And the trebuchet fires the ball. Jill is left standing there because the ball just went right over her head. Should Jack still be on the ball or not? I think we better save Jack. Jack dives off at the last second and hangs onto the frame of the trebuchet. The ball shoots back through the portal and comes into this dimension, flies up into the air and hits Evil Mr. Fred. And squishes him. And they all live happily ever after except Evil Mr. Fred.



Trebuchet on other side of portal.



The ball flies back out through the portal, hits Evil Mister Fred and squishes him.

End of Lesson

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