Q & A: The Human Bodys Resistance

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Q:

please tell value of human body resistance
- thiru (age 21)
india

A:

Thiru -

There are a lot of factors involved and not every person has the same electrical resistance. For instance, men tend to have lower resistance than women. Just like for the resistors used in electronics, the resistance of a person's arm depends on the arm's length and diameter. Resistance goes up with length and down with diameter. Since men tend to have thicker arms and legs (more muscle), they usually have lower resistance. (An implication of this is that the lethal current for men is higher than that for women.) A rough value for the internal resistance of the human body is 300-1,000 Ohms. Naturally, the resistance also depends on the path that electricity takes through the body - if the electricity goes in the left hand and out the right foot, then the resistance will be much higher than if it goes in and out of adjacent fingers.

Within the body, the tissues with the greatest resistance are bone and fat - nerves and muscle have the least resistance. That said, the majority of the body's resistance is in the skin - the dead, dry cells of the epidermis (the skin's outer layer) are very poor conductors. Depending on the person, the resistance of dry skin is usually between 1,000-100,000 Ohms. The skin's resistance is much lower if it is wet or burnt/blistered. This means that when a person is electrocuted in real life, the body's resistance drops as the skin is burned. To determine a person's total resistance, just add together the resistance of each part of the body - remember that the electricity must pass through the skin twice (on the way in and on the way out), so the total resistance is:

$$R_{total} = R_{skin}(in) + R_{internal} + R_{skin}(out)$$

Another interesting point to consider is that in addition to acting like a resistor, the epidermis acts like a capacitor if placed in contact with a piece of metal (the underlying tissue is like one plate of a capacitor and the metal surface is like the other plate - the dry epidermis is the less-conductive material or "dielectric" in between) . In cases of electrocution by a DC voltage source, this capacitive property has little importance. But if the electrocution is by an AC source, the epidermis's natural resistance is "shorted out", allowing the current to bypass that part of the body's resistance and making the body's total resistance much lower.

-Tamara

Reference: R. Fish & L. Geddes, Medical and Bioengineering Aspects of Electrical Injuries, c2003 Lawyers & Judges Publishing Company, Inc.

(published on 10/22/2007)

Follow-Up #1: human conductance

Q:

Not a question, just a sincere THANK YOU for providing a clear and precise answer. I have come across several webpages trying to address this question with vague and sometimes ridiculuous answers. One other page in fact pointed out the AC/DC difference but did not explain the reason (epidermis as dieletric)- now it makes sense.
- Marco (age 32)
San Diego, USA

A:

Thanks!
Mike W.

By the way, you can see the original post, it's # 6793.
LeeH

(published on 08/04/2009)

Follow-Up #2: Series or parallel resistance in electrical shocks?

Q:

do we get electricity shocks in periods when we touch high voltage AC source? also when dc current passes throgh us do we vibrate or experience shocks in period? in one of ur privious answers uve given that Rtotal = Rskin(in) + Rinternal + Rskin(out),i dont agree as u cannot consider as a series connection,it is a parallel one.
- raghavendra
bangalore,karnataka ,india

A:

I think the previous answer is correct. In an electrical shock the current first has to pass through the skin, then it has to pass through the body, finally it has to pass through the skin again. That sounds like series to me.

LeeH

(published on 08/25/2010)

Follow-Up #3: Stopping watches and laptops?

Q:

I know this will sound stupid but here it goes... Can the human body stop watches and laptops?
- Rosemary (age 37)
Dickinson, TX USA

A:

I find it hard to believe a human body stopping a watch, unless the human hand dropped the watch from a high distance. Stopping a laptop though is a different matter. I once destroyed my laptop's wireless card on a cold winter's day by scuffling across a rug and touching it before discharging my self. A big spark did it. Other than static electricity I can't see other human body phenomena that would do it, except clumsiness.

LeeH

(published on 08/22/2011)

Follow-Up #4: Human capacitance (in Farads)

Q:

How does the human body act as capacitor?
- aru (age 25)
chennai,tamil nadu,india

A:

Electrical capacitance is defined by the amount of static charge on a body divided by the voltage of the body with respect to some reference ground. For an isolated spherical body of radius R with an accumulated charge Q the voltage with respect to a ground at infinity (or very far away compared to R), is $V = Q/(4*pi*epsilon_o)/R$ which results in $C = 4*pi*epsilon_o*R$.
For R = 1 meter C = 111 picoFarads. Actual measured values of human body capacitance (to distant ground) vary from 100 to 200 picoFarads. By the way, $epsilon_o$ is the experimentally measured permitivity of free space.

LeeH

(published on 10/22/2007)

Follow-Up #5: Dangers of low and high voltage shocks

Q:

which is the most dangerous low voltage or high voltage?
- Ariel (age 17)
gensan.phil.

A:

The danger of electrical shock depends mainly on the total current flowing through the body. The current, according to Ohm's Law, is proportional to the voltage divided by the total resistance of the circuit. This includes the skin resistance plus the body's internal resistance. The skin resistance can vary by a factor of 100 or more depending whether the skin is dry or moist with salty sweat. For the same value of skin resistance the higher the voltage, the more danger of severe shock. For the same value of voltage, the wetter the skin contact, the more danger. Take your pick.

I have marked this answer as a follow-up to question number 6793 that discusses some other aspects of electrical shocks.

LeeH

(published on 06/20/2012)

Follow-Up #6: low reading for hand-held resistor

Q:

Hey, thanks for your time I was in the lab, and was testing a 100k resistor. With the resistor in my hands, the multimeter read 47k ohlms. Didn't matter how hard or soft i held it. 3 others of my piers all read 87k olhms or greater. Why would there be such a difference?
- matt (age 29)
Canada

A:

This sounds quite peculiar. What's particularly odd is that 47kΩ is a standard resistor value. Ignoring that, could your hands have been sweaty?

Mike W.

(published on 04/04/2013)

Follow-Up #7: safety circuit on boat

Q:

I bought a remote control electric boat at a mall isle booth, which has a "feature" that it only works if it's in the water, or if you have the top off, if you touch each of the 2 brass propeller shafts with your hand. That circuit, which includes the hand or water is in series with the on/off switch for the boat. How can this work? It is a "Superlative" Misquito pre-assembled boat made in China.
- Richard Meckstroth (age 69)
Vonore

A:

I don't think there's any way that the water connection between the shafts could be in series with the motor.

The resistance is much too high. Instead, I bet there's a separate circuit including the water between the shafts through which a small current flows that controls some switch on the main motor circuit. Thus the shaft-to-shaft connection would be in series with the on-off switch, as you found, but not in series with the motor.

Presumably that's done for some sort of protective reason. Perhaps if the motor runs freely in air it overheats.

Mike W.

(published on 08/18/2013)

Follow-Up #8: boat safety switch

Q:

That's the most intelligent/useful response I have gotten so far. No one on the model boat forums seems to know. Yes, the on-off switch goes to a sealed electronic box, so I agree that that part of the circuit doesn't take the full current of the motors. I'm still surprised that either your hand across the brass shafts, or them being in the water will activate the boat electrical system. I wonder if it is resistance or capacitance that affects the circuit. My voltmeter (9 volt battery driven)won't measure any resistance across my hand, it shows infinite.
- Richard Meckstroth (age 69)
Vonore

A:

Yes, I was also wondering if it relies more on resistance or capacitance. If it works with de-ionized water I bet it's capacitance, since the resistivity is so high. It doesn't really matter much for the safety switch circuit, which is unlikely to notice the phase of the current.

Mike W.

(published on 08/19/2013)

Follow-Up #9: Controlling an I-Pad touch screen

Q:

Hi thank you for your great knowledge. Question: I would like to control my IPad touch screen without touching it. A stylus pen is a conduit for the bodies electric field. I want to create the bodies electric field mechanically with no human connection. Is that possible and what would it take? IE: batteries, chip?
- scott (age 45)
haverhill, ma

A:

The capacitative sensors on the Ipad screen will pick up the presence of any conductor or very high dielectric-constant material very close to the screen, since those increase the capacitance of the closest capacitors. You can get styli with conducting tips for the Ipad. You don't need the capacitance to ground

provided by the body. The styli could be manipulated by anything.

(Most other touch screens use little resistive switches activated by mechanical pressure. Their styli usually aren't conductive, so they won't work with the Ipad.)

Mike W.

(published on 08/23/2013)

Follow-Up #10: contacting ipad

Q:

You didn't answer follow up #9 the way he wanted. He already knew what you said in the answer. He was asking if there is a way to emulate the electric field of a human finger, without connection to the human body. Not like existing styli. Say you're a robot, and you need to use an iPhone. How would you interface with the screen?
- Eli (age 23)
California

A:

Actually, what we said couldn't have been what the previous questioner already knew since we contradicted one of his assumptions. There's no need to emulate the electric field of a finger connected to a body. The only thing that's needed is to have some conductor or very high dielectric constant material to perturb the field coming from the screen. If for some reason your robot wanted to closely emulate a finger, it could use a little bag of saltwater.

Mike W.

(published on 05/16/2014)

Follow-Up #11: home-made touch-screen stylus

Q:

Science isn't about NEED, it's about WANT. Yes, it fulfills needs, but it's no fun to only think about needs. We don't need lightsabers or hoverboards. But you know we all damn well want them. Interesting about the saltwater bag. I didn't know that. But let me be more direct and honest: I I want to use a stylus on my ipad that has the fine tip(ballpoint pen status) and projects the same electric field that a human finger does(since the sensor grid refuses to acknowledge anything less than 4mm in width), so as to change the voltage of the capacitors surrounding the tip just like touching the glass with a finger does. And before you say "buy one" I refuse. I will not pay 50 dollars for defective products(customer reviews are terrifying), and the Bluetooth styli are too expensive/fancy for me want them. But most important of all: I want to make it myself. It's fun. It's educational. So: how do I do it?
- Eli (age 23)
California

A:

Avoiding the high prices of store-bought styli sounds like a nice idea. Here's a guess about what might work well. Take a a little metal rod a few mm thick with a nice rounded end. You could even round an end with a file. Then coat the rod with some thin plastic stuff. Coatings like that are available iin hardware stores for not much cost. The purpose of the coating is to prevent damaging the screen when your home-made stylus accidentally touches it.

Since we don't really have any experience in this business, please do not sue us for damaging your screen if something screws up.

Mike W.

(published on 05/16/2014)

Follow-Up #12: cheap capacitance measurement

Q:

Hi, thank you for your help. May I can I measure the capacitance of a material? For example, the thin plastic stuff that was stated in the previous answer. How would you measure the capacitance, using a cheap way if possible?
- Jordan (age 25)
Singapore

A:

How to measure the capacitance of some little capacitor depends a lot on what you have available. The easiest way is (no surprise here) to use a capacitance meter. It looks like you can get one for about $70 (US) that will measure small enough capacitance. If you happen to already have an oscilloscope with a high-impedance input, you can charge up the capacitor with a battery and then let the charge drain off through a big resistor while monitoring the voltage on the scope. The drain time (to about 40% of the initial voltage) is RC, the resistance times the capacitance. There are all sorts of variations on this theme, such as seeing how much ac current flows through the capacitor for a particular ac voltage, in case you have an ordinary ac meter to measure current and voltage and some suitable source of ac voltage. The current magnitude will be $2\pi VCf$, where f is the frequency. Don't use voltage from standard outlets. It's too big and could kill you or damage your little capacitor. You want a small voltage, and probably at much higher frequency to make the current through the capacitor big enough to measure.

Mike W.

(published on 06/10/2014)

Follow-Up #13: Capacitive coupling & you

Q:

Have there been any studies into the impact of constantly using our bodies (body capacitance) to make the touch screen devices work? There are plenty of studies showing the impact of technology on our capacity to think, reason, learn. Surely there has to be an enormous impact from having all these cellphone transmissions flying through the air. And, as well, an impact from constantly using touch screens. Before,

the idea that cell phone usage could cause cancer in the brains of people who hold cell phones to their bodies repeatedly was viewed as absurd (sounding eerily similiar to claims that smoking doesn´t cause cancer), and now evidence is growing. Constantly using body capacitance through the use of touch screens has to have an impact, as well. Any real studies been done on this? Yes, I know the standard response is that it´s such a small amount of electricity -- but a constant dripping of water on a rock will eventually wear a hole through it.
- Peter (age 46)
Beaver Dam, WI, USA

A:

It's okay to disagree with the standard response. But ask yourself this: "What would convince me that I'm wrong?"

Be specific. What standards would a study have to adhere to? Who would you trust to do it right? Would it need to be repeated by others? If the result didn't support what you already believe, would you suspect the truth was being covered up somehow? If you can't think of anything that would convince you, that should be a warning that you're letting yourself be guided more by how you feel about the issue than by evidence. Scientists have to be careful about this stuff, too.

With that said, I'm not aware of any studies on the long-term safety of capacitive touch screens. It's always possible that there's some harmful effect we haven't predicted, but the "standard response" that the amount of charge involved is very small makes a lot of sense. Rocks and water don't have anything to do with it.

One more thing to think about—if touch screens were harmful, every other conductive surface you touch (metal, water, other people) probably would be too. Capacitive coupling happens between any two conductors seperated by an insulator such as air, glass, or dirt. Touch screens just provide a conductive surface, an insulator, and a way to measure the local change in capacitance caused by your finger.

Rebecca Holmes

(published on 09/22/2014)

Follow-Up #14: Testing touch screens

Q:

Rebecca, Thanks for your response, it is appreciated. Yes, the scientific method is in general a very helpful tool of great value. The world of science, however, is often warped away from the scientific method (think tobacco company scientists providing evidence that cigarettes dont cause cancer, or oil company scientists providing evidence that climate change is not related to man´s activities, etc). Many times what was thought safe later turns out not to be; and the fact that there have been no studies (that either you or I know if, at least) looking into the impact of the use of touch screen technologies sends up a warning sign, for me. Before, when I used to keep my cell phone in my front left pants pocket, the top of my left leg, just above the knee, started going numb. When I stopped putting the phone there, the numbness went away. The industry said for years that cell phones are safe, yet now more and more evidence is mounting to the contrary. Laptops cause sperm count reduction in men. Industry tends to move things forward without testing things well enough, and without testing them in terms of systemic impact. These days, when I use touch screen technology I feel a strange sensation in my fingertips (much like the knee thing) and it gives me the gut feeling that something isn´t right. I´m not a paranoid person, I like things based on evidence,

thus I asked the question here to this forum have there been any studies into this? I am an educator, among other things, and with years of studying pedagogy I have found that the best education tends to be a balance of three things: [received knowledge: what´s in the box] + [critical thinking: the fact that it IS a box; that if we change what we focus on or how we focus on it, often the information we receive changes] + [creativity: thinking outside of the box]. A balance of these three is best, in my view, yet we all too often focus on the first part, received knowledge. Take the average debate on TV about the Iraq War (now with Syria and Iran) and it looks like, Should we bomb them now or later? The debate has been framed; excluded are the ideas of not bombing Iraq at all, or removing our military bases from all around the world, or diplomacy, or or or Same, too, it seems to me happens in the world of science. Funding is given for some projects and some ideas, not others, which means certain info is generated and other info is not. Neil Postman writes about this (as it relates to technology) fairly well in his book Technopoly. And, as I mentioned before, there is also the very important question of systems thinking that is often overlooked. From the book Natural Capitalism: Consider what happened in Borneo in the 1950s. Many Dayak villagers had malaria, and the World Health Organization had a solution that was simple and direct. Spraying DDT seemed to work: Mosquitoes died, and malaria declined. But then an expanding web of side effects ('consequences you didn't think of,' quips biologist Garrett Hardin, 'the existence of which you will deny as long as possible') started to appear. The roofs of people's houses began to collapse, because the DDT had also killed tiny parasitic wasps that had previously controlled thatch-eating caterpillars. The colonial government issued sheet-metal replacement roofs, but people couldn't sleep when tropical rains turned the tin roofs into drums. Meanwhile, the DDT-poisoned bugs were being eaten by geckos, which were eaten by cats. The DDT invisibly built up in the food chain and began to kill the cats. Without the cats, the rats multiplied. The World Health Organization, threatened by potential outbreaks of typhus and sylvatic plague, which it had itself created, was obliged to parachute fourteen thousand live cats into Borneo. Thus occurred Operation Cat Drop, one of the odder missions of the British Royal Air Force." One could go on and on, but I return to my main point: we really don´t know because it hasn´t been studied. To assume is not good, and go forward to a mass global scale (think of all the touch screens everywhere) without questioning the obvious seems to me to be neither scientific nor wise. Peace, Peter
- Peter (age 46)
Beaver Dam, WI, USA

A:

Peter,

Thanks for all your thoughtful points. If you could show that there's really a sensation associated with using touch screens, you might be able to get someone interested in studying it more. One way to do that would be to ask an assistant with a random number generator to randomly present you with a real or "fake" touch screen (maybe a piece of glass made to look and feel identical, or maybe just the same touch screen turned off) many times, and see if you can reliably tell the difference between them (reliably = better than 50% with statistical significance).

It would be even more convincing to get a bunch of volunteers, have half of them touch active touch screens, and have half of them touch fakes. Then you could ask them to rate something about the way their fingers feel, and look for a difference between the two groups. None of this would prove anything about a harmful effect, but it would be somewhere to start.

As a physicist, I have to stick to my educated guess that there's no physical reason why touch screens would be dangerous.

Rebecca Holmes

(published on 09/29/2014)

Follow-up on **this answer**.