

Re: Capacitor and Force

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- *From:* "Jon Slaughter" <Jon_Slaughter@xxxxxxxxxxx>
 - *Date:* Sat, 13 Oct 2007 12:12:33 GMT
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"The Phantom" <phantom@xxxxxxx> wrote in message
news:pad0h3df4mvk2fdl348gaf36g70e7slcma@xxxxxxxxxxx

On Fri, 12 Oct 2007 22:48:59 GMT, "Jon Slaughter"
<Jon_Slaughter@xxxxxxxxxxx> wrote:

Heres the problem, due to John Perry.

My assumption about ceramic caps was wrong. I didn't know it was layered.

Since one has layers the charge is distributed between each layer. Suppose there are $2n$ interleaved layers and charge Q . Then each layer has charge Q/n . Every layer experiences a force between every other but almost all cancel out.

By assuming all the charge Q was on just one plate seperated by a distance r was wrong(Which is how jus 2 plates would actually work).

Some initial investigation shows that the layers have a significant effect in reducing the force. No only is the charge on each plate reduced by Q/n but the distance between the first and last is increased because of all the layers inbetween. So treating a ceramic cap as a parallel plate cap is wrong as I did it. (using CV to get the charge and assuming it was on each plate because it should be Q/n but I have no idea what n is).

So there are forces there but they are much smaller than what I was thinking. For a very large parallel plate cap one has $C = e^*A/d$, $Q = C*V$,
 F
 $= k*(Q/d)^2 = k*(e^*A/d*V/d)^2 = k*(e^*A*V/d^2)^2$.

You seem particularly resistant to the notion that you are using the wrong formula to compute the force between the plates of a parallel plate capacitor. The formula for the force between point charges won't give the

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correct result. You have to divide the plates up into little $dx dy$ pieces, with each having the appropriate little bit of the total charge on a plate, and integrate the force between each little bit of charge on one plate and all the little bits on the other plate. See:

Yes I am resistant because the formula applies to this situation. I might be making some mistake in applying it but that is a totally different story from using the wrong formula.

I know you can use calculus for the general case and that can be done but it shouldn't result in any significant difference in this case (because of the large degree of symmetry) and actually my result *should* be a lower bound since I don't take into account any forces acting at an angle.

http://web.utk.edu/~kamyshko/P231/Problem_HW_Chapter24_Force_Between_Plates.pdf

and:

<http://mysite.du.edu/~jcalvert/phys/caps.htm>

The second reference goes through the integration necessary, and even gives an example of plates of dimensions 10 cm X 10 cm and 1 mm spacing charged to 300 volts. Their calculated force is .00398 newtons (398 dynes).

Using your formula $k \cdot (e \cdot A \cdot V / d^2)^2$ and plugging in their numbers:

$$k = 8.988E9$$

$$e = 8.854E-12$$

$$A = 10\text{cm} \cdot 10\text{cm} = .01 \text{ m}^2$$

$$V = 300$$

$$d = 1\text{mm} = .001 \text{ m}$$

we get 6.34 newtons, considerably more than the .00398 newtons they got.

I do not know why the results are so significantly different. Obviously the formula I wrote above doesn't come out with any reasonable answer and is several orders of magnitude off. (it should actually be lower) I either there is a factor wrong or something else is wrong. The logic itself should work just fine and it's exactly the logic that site uses except I do not

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worry about charges that are not directly across from any other.

I think that is my problem though. I'm computing Q^2 which gives the interaction force between every pair of charges but doesn't take into account the angle at which the forces act so its treating it as if the force is always constant for every particle pair. So actually I'm guessing what I should have is $k \cdot (Q/A) \cdot (Q/A) / d^2 \cdot A$ (as an approximation.. dimensions are wrong of course)

in this case I get about 0.006N for the example above. So the real problem, like a few have mentioned is that its wrong to assume that all the charge is concentrated at a point because when I do this I'm basically saying the force is the same over a all charge pairs when its definitely not. By realizing that the force is really only that strong for one pair and then gets drastically weaker(which for my approximation I just say its 0) I get a much more reasonable approximation. But in this case it should be lower and its still higher ;/

I'll work on it some more and see if I can still apply the coulombs law or not. I do think it can be used as a first approximation but it needs to be used properly instead of blindly like I did. (Actually my result works well if the distance between the plates is much larger than the size instead of vice versa).

Thanks,
Jon