Re: Capacitor and Force

Source: http://sci.tech−archive.net/Archive/sci.electronics.design/2007−10/msg02416.html

- *From*: Tom Bruhns <k7itm@xxxxxxx>
- *Date*: Sat, 13 Oct 2007 12:08:14 −0700

On Oct 13, 5:12 am, "Jon Slaughter" <Jon_Slaugh...@xxxxxxxxxxx> wrote:

> "The Phantom" <phan...@xxxxxxx> wrote in message
>
> news:pad0h3df4mvk2fdl348gaf36g70e7slcma@xxxxxxxxxx
>
>> On Fri, 12 Oct 2007 22:48:59 GMT, "Jon Slaughter"
>> <Jon_Slaugh...@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
> correct result. You have to divide the plates up into little dxdy 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 different 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_...

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*(e*A*V/d^2)^2 and plugging in their numbers:

k = 8.988E9

e = 8.854E−12

A = 10cm * 10cm = .01 m^2

V = 300

d = 1mm = .001 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 its exactly the logic that site uses except I do not 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 doens't take into account the angle at which the forces act so its treating it as a if the force is always constant for every particle pair. So actually I'm guessing what I should have is k*(Q/A)*(Q/A)/d^2*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 reasonble 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 coulumbs 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

Jon, please consider this simple example; perhaps then you will see why Phantom's explanation is right on. Consider two point charges, let's say equal magnitude and opposite polarity, separated by a distance x. They are attracted with force F. If I have another identical pair, they will also be attracted by F. So if the two pairs are at a distance from each other much greater than x, the total force will be 2*f. But if I bring them together, so the like charges are at the same points, the force will be 2^2 or 4 times as much. OK? It really DOES matter how in space the charges are distributed.

As Phantom says, the SAME is true for gravitational attraction; two massive plates separated by x where x is small compared with the extent of the plates will not be attracted with the same force as two point masses separated by x.

Cheers,
Tom

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