LAMPIRAN I

Analisis Data Konstanta Dielektrik ε_r pada Udara

d = 0,013 m

Δ E = 50 Volt/m

Δ V = 0,5 volt

Δ d = 0,00005 m

No	V (Volt)	E (kilovolt)	E (volt)	ε_r
1	381	25,2	25300	0,85984252
2	434	28,6	28600	0,856682028
3	451	29,8	29800	0,858980044
4	517	34,2	34200	0,859961315
5	530	35,1	35100	0,860943396
6	575	38,1	38100	0,861391304
7	605	39,9	39900	0,857355372
8	706	46,7	46700	0,859915014
9	743	49,1	49100	0,859084791
10	819	54,3	54300	0,861904762

Contoh perhitungan konstanta dielektrik untuk data no 1,

$$\varepsilon_r = \frac{E\ d}{V}$$

$$\varepsilon_r = \frac{25300 \text{ x } 0{,}013}{381} = 0{,}85984252$$

Penurunan Rumus

No	$\left\|\frac{\partial \varepsilon_r}{\partial E}\right\|$	$\left\|\frac{\partial \varepsilon_r}{\partial d}\right\|$	$\left\|\frac{\partial \varepsilon_r}{\partial V}\right\|$	$\Delta\varepsilon_{r_i}$
1	3,41207 x 10 $^{-5}$	66,14173228	0,002256805	0,004487982
2	2,99539 x 10 $^{-5}$	65,89861751	0,001973922	0,004132122
3	2,88248 x 10 $^{-5}$	66,07538803	0,001904612	0,004045432
4	2,51451 x 10 $^{-5}$	66,15087041	0,001663368	0,003742709
5	2,45283 x 10 $^{-5}$	66,22641509	0,001624422	0,003694286
6	2,26087 x 10 $^{-5}$	66,26086957	0,001498072	0,003535992
7	2,14876 x 10 $^{-5}$	65,95041322	0,001417116	0,003431699
8	1,84136 x 10 $^{-5}$	66,14730878	0,00121801	0,003183368
9	1,74966 x 10 $^{-5}$	66,08344549	0,001156238	0,003105037
10	1,5873 x 10 $^{-5}$	66,3003663	0,001052387	0,002977353

Contoh perhitungan untuk data no 1 :

a. $\left|\frac{\partial \varepsilon_r}{\partial E}\right| = \frac{d}{V}$

$$\left|\frac{\partial \varepsilon_r}{\partial E}\right| = \frac{0{,}013}{434} = 3{,}41207 \text{ x } 10^{-5}$$

b. $\left|\frac{\partial \varepsilon_r}{\partial d}\right| = \frac{E}{V}$

$$\left|\frac{\partial \varepsilon_r}{\partial d}\right| = \frac{28600}{434} = 66{,}14173228$$

c. $\left|\frac{\partial \varepsilon_r}{\partial V}\right| = \left|-\frac{E\ d}{V^2}\right|$

$$\left|\frac{\partial \varepsilon_r}{\partial V}\right| = \left|-\frac{28600x\ 0{,}013}{434^2}\right| = 0{,}002256805$$

d. $\Delta\varepsilon_{r_i} = \left|\frac{\partial\varepsilon_r}{\partial E}\right| \ x\ \Delta E + \left|\frac{\partial\varepsilon_r}{\partial d}\right| \ x\ \Delta d \ + \left|\frac{\partial\varepsilon_r}{\partial V}\right| x\Delta V$

= (3,41207 x 10 $^{-5}$ x 50) + (66,14173228 x 0,00025) + (0,002256805 x 0,5)

= 0,004487982

Setelah data – data di atas diperoleh, dihitung konstanta dielektrik rata – rata ($\overline{\varepsilon_r}$) dan ketidakpastian ($\Delta\overline{\varepsilon_r}$) dengan menggunakan w_i sebagai berikut :

$$w_i = \left(\frac{1}{\Delta\varepsilon_{r_i}}\right)^2$$

$$\overline{\varepsilon_r} = \frac{\sum w_i \varepsilon_{r_i}}{\sum w_i} \qquad \overline{\Delta\varepsilon_r} = \frac{1}{\sqrt{\sum w_i}}$$

Misalnya untuk $\varepsilon_{r_i} = 0{,}85984252$ dan $\Delta\varepsilon_r = 0{,}004487982$ maka $w_i = \left(\frac{1}{0{,}004487982}\right)^2 = 49647{,}53919$

No	ε_{r_i}	$\Delta\varepsilon_{r_i}$	w_i	$w_i\varepsilon_{r_i}$
1	0,85984252	0,035905305	775,6802898	666,9628949
2	0,856682028	0,035433965	796,4536094	682,307493
3	0,858980044	0,035431242	796,576067	684,2429454
4	0,859961315	0,035164373	808,7126799	695,4616199
5	0,860943396	0,035151833	809,2897458	696,7526623
6	0,861391304	0,035009905	815,8646634	702,7787266
7	0,857355372	0,034758145	827,7264253	709,6556972
8	0,859915014	0,034603339	835,149026	718,1571865
9	0,859084791	0,034494673	840,4191181	721,9912827
10	0,861904762	0,034470027	841,6213511	725,3974503

$\sum$wi = 8147,492976

$\sum w_i \varepsilon_{r_i} = 7003{,}707959$

$$\bar{\varepsilon_r} = \frac{\sum w_i \varepsilon_{r_i}}{\sum w_i}$$

$$\bar{\varepsilon_r} = \frac{7003{,}707959}{8147{,}492976} = 0{,}859615096$$

$$\overline{\Delta\varepsilon_r} = \frac{1}{\sqrt{\sum w_i}} = \frac{1}{\sqrt{8147{,}492976}} = 0{,}01107868$$

Kesalahan Relatif = $\frac{\overline{\Delta\varepsilon_r}}{\bar{\varepsilon_r}}$ x 100 %

$$= \frac{0{,}01107868}{0{,}859615096} x\ 100\ \% = 1{,}288795375\ \%$$

Keseksamaan = 100 % - Kesalahan Relatif

= 100 % - 1,288795375

= 98,71120463%

Angka Berarti =$1 - log \frac{\overline{\Delta\varepsilon_r}}{\bar{\varepsilon_r}} = 2{,}889816031 \approx 3AB$

Harga Sebenarnya =($\bar{\varepsilon_r} \pm \overline{\Delta\varepsilon_r}$) = (8,60 $\pm$ 0,10) x 10^{-1}

LAMPIRAN II

Analisis Data Konstanta Dielektrik ε_r pada Plastik

t = 0,004 m

d = 0,013 m

Δ E = 50 Volt/m

Δ V = 0,5 volt

Δ d = 0,00005 m

Δ t = 0,000025 m

No	V (Volt)	E (kilovolt)	E (volt)	ε_r
1	365	33,6	33600	2,146964856
2	396	36,7	36700	2,234398782
3	434	39,7	39700	2,070404172
4	449	41,5	41500	2,198675497
5	475	44,1	44100	2,258642766
6	478	44,6	44600	2,328981723
7	523	48,2	48200	2,161434978
8	551	50,5	50500	2,093264249
9	652	59,8	59800	2,101933216
10	941	85,7	85700	2,020035357

Contoh perhitungan data no 1 :

$$\varepsilon_r = \frac{E\ t}{V - E\ d + E\ t}$$

$$\varepsilon_r = \frac{33600\ x\ 0{,}004}{365 - (33600\ x\ 0{,}013) + (33600 x\ 0{,}004)}$$

$$\varepsilon_r = \frac{134{,}4}{365 - 436{,}8 + 134{,}4}$$

$$\varepsilon_r = \frac{134{,}4}{62{,}6} = 2{,}146964856$$

No	$\left\|\frac{\partial \varepsilon_r}{\partial E}\right\|$	$\left\|\frac{\partial \varepsilon_r}{\partial V}\right\|$	$\left\|\frac{\partial \varepsilon_r}{\partial d}\right\|$	$\left\|\frac{\partial \varepsilon_r}{\partial t}\right\|$	$\Delta\varepsilon_{r_i}$
1	$9{,}81943 \times 10^{-5}$	0,034296563	1071,643359	1945,329591	0,097482322
2	$9{,}48919 \times 10^{-5}$	0,034009114	1356,038967	2343,647104	0,114241304
3	$7{,}91448 \times 10^{-5}$	0,026993535	1167,950291	1994,320467	0,096510775
4	$8{,}21017 \times 10^{-5}$	0,02912153	1095,438804	1882,869339	0,093123552
5	$8{,}01363 \times 10^{-5}$	0,028919882	1208,543485	3489,936406	0,135928752
6	$8{,}26238 \times 10^{-5}$	0,030404461	1768,383988	6362,133697	0,222596362
7	$6{,}90744 \times 10^{-5}$	0,024231334	769,2807192	1357,383814	0,068735999
8	$6{,}31426 \times 10^{-5}$	0,021691857	664,9772079	1000,0618	0,055629036
9	$5{,}36198 \times 10^{-5}$	0,018470415	1275,366786	5919,598138	0,191790321
10	$3{,}54746 \times 10^{-5}$	0,011903567	1152,364523	18779,05001	0,506010876

Contoh Perhitungan data no 1 :

a. $\left|\frac{\partial \mathrm{\varepsilon_r}}{\partial \mathrm{E}}\right| = \frac{\mathrm{t(V-Ed-Et)-\ Et(-d+t)}}{\mathrm{(V-Ed+E\ t)^2}}$

$$\left|\frac{\partial \mathrm{\varepsilon_r}}{\partial \mathrm{E}}\right| = \frac{0{,}004(365-(33600 \times 0{,}013)-(33600 \times 0{,}004)-\ (33600 \times 0{,}004)(-0{,}013+0{,}004)}{(365-(33600 \times 0{,}013)+(33600 \times 0{,}004\ ))^2}$$

$$\left|\frac{\partial \mathrm{\varepsilon_r}}{\partial \mathrm{E}}\right| = 9{,}81943 \times 10^{-5}$$

b. $\left|\frac{\partial \varepsilon_r}{\partial V}\right| = \frac{-\ Et}{(V-Ed+E\ t)^2}$

$$\left|\frac{\partial \varepsilon_r}{\partial V}\right| = \frac{-\,33600\ x\ 0{,}004}{(365-(33600\ x\ 0{,}013)+(33600\ x\ \ 0{,}004))^2} = \ 0{,}03429656$$

c. $$\left|\frac{\partial \varepsilon_r}{\partial d}\right| = \frac{E^2 t}{(V-Ed+E\ t)^2}$$

$$\left|\frac{\partial \varepsilon_r}{\partial d}\right| = \frac{33600^2 x\ 0{,}004}{(365-(33600\ x0{,}013)+(33600\ x\ 0{,}004))^2} = \ 1071{,}643359$$

d. $$\left|\frac{\partial \varepsilon_r}{\partial t}\right| = \frac{E(V-Ed-Et)-\ E^2 t}{(V-Ed+E\ t)^2}$$

$$\left|\frac{\partial \varepsilon_r}{\partial t}\right| = \frac{33600(365-(33600\ x\ 0{,}013)-(33600\ x\ 0{,}004)-\ (33600^2 x\ 0{,}004)}{(365-(33600\ x0{,}013)+(33600\ x\ 0{,}004))^2}$$

$$\left|\frac{\partial \varepsilon_r}{\partial t}\right| = 1945{,}329592$$

e. $$\Delta \varepsilon_{r_i} = \left|\frac{\partial \mathrm{\varepsilon_r}}{\partial \mathrm{E}}\right| \text{ x } \Delta \mathrm{E} + \left|\frac{\partial \mathrm{\varepsilon_r}}{\partial \mathrm{d}}\right| \text{ x } \Delta \mathrm{d} + \left|\frac{\partial \mathrm{\varepsilon_r}}{\partial \mathrm{V}}\right| \text{x} \Delta \mathrm{V} + \left|\frac{\partial \mathrm{\varepsilon_r}}{\partial \mathrm{t}}\right| \text{ x } \Delta \mathrm{t}$$

= (9,81943 x 10^{-5} x 50) + (0,034296563 x 0,5) (1071,643359 x 0,0005) + (1945,329591 x 0,00025)

= 0,606512917

Setelah data – data diatas diperoleh langkah berikutnya yaitu menghitung konstanta dielektrik rata – rata ($\overline{\varepsilon_r}$) dan ketidakpastian ($\Delta\overline{\varepsilon_r}$) dengan menggunakan w_i sebagai berikut :

$$w_i = \left(\frac{1}{\Delta \varepsilon_{r_i}}\right)^2$$

$$\overline{\varepsilon_r} = \frac{\sum w_i \varepsilon_{r_i}}{\sum w_i}$$

$$\overline{\Delta\varepsilon_r} = \frac{1}{\sqrt{\sum w_i}}$$

Misalnya untuk $\varepsilon_{r_i} = 2{,}146964856$ dan $\Delta\varepsilon_r = 0{,}606512917$maka $w_i = \left(\frac{1}{0{,}606512917}\right)^2 = 2{,}718440868$

Dari nilai ε_r yang diperoleh sebelumnya dihitung w sebagai berikut :

No	ε_{r_i}	$\Delta\varepsilon_{r_i}$	w_i	$w_i\varepsilon_{r_i}$
1	2,146964856	0,606512917	2,718440868	5,836397008
2	2,234398782	0,758359814	1,738798983	3,885170331
3	2,070404172	0,651287163	2,357517705	4,881014492
4	2,198675497	0,613456983	2,657246054	5,842421787
5	2,258642766	0,709986907	1,983806551	4,480710316
6	2,328981723	1,062578756	0,885681844	2,062736828
7	2,161434978	0,434144341	5,305565874	11,46763566
8	2,093264249	0,371493209	7,245998516	15,16778964
9	2,101933216	0,797589544	1,571958572	3,304151937
10	2,020035357	1,053384024	0,901211127	1,820478339

∑Wi = 27,36622609

$\sum w_i\varepsilon_{r_i} = 58{,}74850633$

$$\bar{\varepsilon_r} = \frac{\sum w_i\varepsilon_{r_i}}{\sum w_i}$$

$$\bar{\varepsilon_r} = \frac{58{,}74850633}{27{,}36622609} = 2{,}146752209$$

$$\overline{\Delta\varepsilon_r} = \frac{1}{\sqrt{\sum w_i}}$$

$\overline{\Delta\varepsilon_r} = \frac{1}{\sqrt{27,36622609}} = 0,191158029$

Kesalahan Relatif $= \frac{\overline{\Delta\varepsilon_r}}{\overline{\varepsilon_r}} \text{x } 100\ \%$

$= \frac{0,191158029}{2,146752209} x\ 100\ \%$

$= 8,904522304\ \%$

Keseksamaan = 100 % - Kesalahan Relatif

= 100 % - 8,904522304 %

= 91,0954777 %

Angka Berarti =$1 - log\frac{\overline{\Delta\varepsilon_r}}{\overline{\varepsilon_r}} = 1 - log\frac{0,191158029}{2,146752209} = 2,050389374 \approx 2AB$

Harga Sebenarnya =($\overline{\varepsilon_r} \pm \overline{\Delta\varepsilon_r}$) = $2,1 \pm 0,2$

LAMPIRAN III

Analisis Data Konstanta Dielektrik ε_r pada Kaca

t = 0,004 m
d = 0,0124 m
Δ E = 50 Volt/m
Δ V = 0,5 volt
Δ d = 0,000025 m
Δ t = 0,000025 m

No	V (Volt)	E (kilovolt)	E (volt)	ε_r
1	369	39,5	39500	4,247311828
2	386	41,2	41200	4,128256513
3	429	45,8	45800	4,13730804
4	447	47,9	47900	4,292114695
5	464	49,7	49700	4,273430782
6	518	55,6	55600	4,364207221
7	549	58,7	58700	4,198855508
8	562	60,5	60500	4,498141264
9	594	63,8	63800	4,393939394
10	664	71,6	71600	4,578005115

Contoh perhitungan data no 1 :

$$\varepsilon_r = \frac{E\ t}{V - E\ d + E\ t}$$

$$\varepsilon_r = \frac{39500\ x\ 0{,}004}{(369 - (39500\ x\ 0{,}0124) + (39500\ x\ 0{,}004))}$$

$$\varepsilon_r = \frac{158}{369 - 489{,}8 + 158} = \frac{158}{37{,}2} = 4{,}247311828$$

No	$\left\|\frac{\partial \varepsilon_r}{\partial E}\right\|$	$\left\|\frac{\partial \varepsilon_r}{\partial V}\right\|$	$\left\|\frac{\partial \varepsilon_r}{\partial t}\right\|$	$\left\|\frac{\partial \varepsilon_r}{\partial d}\right\|$	$\Delta\varepsilon_{r_i}$
1	0,000153197	0,114175049	12467,91537	4509,914441	0,489193115
2	0,000141566	0,103413239	11749,81225	4260,625459	0,459045847
3	0,000127708	0,093435141	11803,66135	4279,329454	0,455177755
4	0,000128066	0,096149523	12743,65774	4605,562139	0,488208536
5	0,000122729	0,091862227	12628,30029	4565,552663	0,481913908
6	0,000112749	0,085639859	13193,6767	4761,576168	0,497338695
7	0,000101565	0,07508683	12173,07681	4407,596894	0,457138532
8	0,000107793	0,083608574	14050,42081	5058,318708	0,524912418
9	$9{,}91318 \times 10^{-5}$	0,075653226	13381,5427	4826,675849	0,497988668
10	$9{,}32098 \times 10^{-5}$	0,073177831	14574,09685	5239,532708	0,536590142

Contoh Perhitungan data no 1 :

a. $$\left|\frac{\partial \varepsilon_r}{\partial E}\right| = \frac{t(V\text{-}Ed\text{-}Et)\text{-}Et(\text{-}d+t)}{(V\text{-}Ed+E\,t)^2}$$

$$\left|\frac{\partial \varepsilon_r}{\partial E}\right| = \frac{0{,}004(369-(39500 \text{ x } 0{,}0124)-(39500 \text{ x } 0{,}004)(-0{,}0124+0{,}004)}{(369-(39500 \text{ x } 0{,}0124)+(39500\text{x } 0{,}004))^2}$$

$$\left|\frac{\partial \varepsilon_r}{\partial E}\right| = 0{,}000153197$$

b. $$\left|\frac{\partial \varepsilon_r}{\partial V}\right| = \frac{-Et}{(V-Ed+E\,t)^2}$$

$$\left|\frac{\partial \varepsilon_r}{\partial V}\right| = \frac{-39500\ x\ 0{,}004}{(369-(39500\ x\ 0{,}0124)+(39500\ x 0{,}004))^2}$$

$$\left|\frac{\partial \varepsilon_r}{\partial V}\right| = 0{,}114175049$$

c. $$\left|\frac{\partial \varepsilon_r}{\partial d}\right| = \frac{E^2 t}{(V - Ed + E\,t)^2}$$

$$\left|\frac{\partial \varepsilon_r}{\partial d}\right| = \frac{39500^2 x\ 0{,}004}{(369 - (39500\ x\ 0{,}013) + (39500\ x\ 0{,}004)\ )^2}$$

$$\left|\frac{\partial \varepsilon_r}{\partial d}\right| = 4509{,}914441$$

d. $$\left|\frac{\partial \varepsilon_r}{\partial t}\right| = \frac{E(V - Ed - Et) - E^2 t}{(V - Ed + E\,t)^2}$$

$$\left|\frac{\partial \varepsilon_r}{\partial t}\right| = \frac{39500(369 - (39500\ x\ 0{,}013) - (39500\ x\ 0{,}004) - (39500^2 x 0{,}004)}{(369 - (39500\ x\ 0{,}013) + (39500\ x\ 0{,}004))^2}$$

$$\left|\frac{\partial \varepsilon_r}{\partial t}\right| = 12467{,}91537$$

e. $$\Delta\varepsilon_{r_i} = \left|\frac{\partial \varepsilon_r}{\partial E}\right| \text{ x } \Delta E + \left|\frac{\partial \varepsilon_r}{\partial d}\right| \text{ x } \Delta d + \left|\frac{\partial \varepsilon_r}{\partial V}\right| \text{x} \Delta V + \left|\frac{\partial \varepsilon_r}{\partial t}\right| \text{ x } \Delta t$$

= (0,000153197 x 50) + (0,114175049 x 0,5) (12467,91537 x 0,00025) + (4509,914441 x 0,00025)

= 0,489193115

Setelah data – data diatas diperoleh langkah berikutnya yaitu menghitung konstanta dielektrik rata – rata ($\overline{\varepsilon_r}$) dan ketidakpastian ($\Delta\overline{\varepsilon_r}$) dengan menggunakan w_i sebagai berikut :

$$w_i = \left(\frac{1}{\Delta\varepsilon_{r_i}}\right)^2$$

$$\overline{\varepsilon_r} = \frac{\sum w_i \varepsilon_{r_i}}{\sum w_i}$$

$$\overline{\Delta\varepsilon_r} = \frac{1}{\sqrt{\sum w_i}}$$

Misalnya untuk $\varepsilon_{r_i} = 4{,}247311828$ dan $\Delta\varepsilon_r = 0{,}489193115$ maka $w_i = \left(\frac{1}{0{,}489193115}\right)^2 = 4{,}178682056$

Dari nilai ε_r yang diperoleh sebelumnya dihitung w sebagai berikut :

No	ε_{r_i}	$\Delta\varepsilon_{r_i}$	w_i	$w_i\varepsilon_{r_i}$
1	4,247311828	0,489193115	4,178682056	17,74816572
2	4,128256513	0,459045847	4,745564431	19,59090727
3	4,13730804	0,455177755	4,826562569	19,96897612
4	4,292114695	0,488208536	4,195553502	18,00779684
5	4,273430782	0,481913908	4,305871646	18,40084444
6	4,364207221	0,497338695	4,042923268	17,64415492
7	4,198855508	0,457138532	4,785246804	20,0925599
8	4,498141264	0,524912418	3,629328719	16,32523327
9	4,393939394	0,497988668	4,032376546	17,71801816
10	4,578005115	0,536590142	3,473078668	15,89977191

$\sum W_i =$ 42,21518821

$\sum w_i \varepsilon_{r_i} = 181{,}3964285$

$$\overline{\varepsilon_r} = \frac{\sum w_i \varepsilon_{r_i}}{\sum w_i}$$

$$\bar{\varepsilon_r} = \frac{181,3964285}{42,21518821} = 4,296947053$$

$$\overline{\Delta\varepsilon_r} = \frac{1}{\sqrt{\sum w_i}}$$

$$\overline{\Delta\varepsilon_r} = \frac{1}{\sqrt{42,21518821}} = 0,153909574$$

Kesalahan Relatif = $\frac{\overline{\Delta\varepsilon_r}}{\overline{\varepsilon_r}}$ x 100 %

$$= \frac{0,153909574}{4,296947053} x\ 100\ \% = 3,581835469\ \%$$

Keseksamaan = 100 % - Kesalahan Relatif

= 100 % - 3,581835469 %

= 96,41816453 %

Angka Berarti =$1 - log\frac{\overline{\Delta\varepsilon_r}}{\overline{\varepsilon_r}} = 1 - log\frac{0,153909574}{4,296947053} = 2,445894367\ \approx 2AB$

Harga Sebenarnya =($\overline{\varepsilon_r} \pm \overline{\Delta\varepsilon_r}$) = (4,3 $\pm$ 0,2)

LAMPIRAN IV

Modul Petunjuk Praktikum

LABORATORIUM FISIKA **LISTRIK MAGNET DAN ELEKTRONIKA**
UNIVERSITAS KATOLIK WIDYA MANDALA SURABAYA

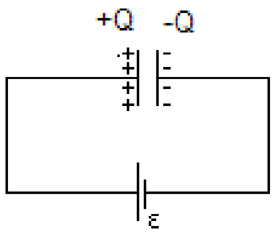
KAPASITOR PLAT SEJAJAR

I. TUJUAN

Agar mahasiswa dapat menentukan permitivitas bahan dielektrik atau konstanta dielektrik melalui eksperimen kapasitor plat sejajar.

II. TEORI

Kapasitor adalah komponen pasif yang dapat menyimpan muatan listrik. Kemampuan untuk menyimpan muatan disebut kapasitansi atau kapasitans (C), dengan satuan farad (F). Kapasitor terdiri atas dua keping konduktor yang terpisah pada jarak tertentu. Bila pada kapasitor diberi beda potensial maka pada kedua keping kapasitor masing-masing akan bermuatan listrik yang besarnya sama tetapi tandanya berbeda. Besar muatan pada kapasitor merupakan besar muatan yang terdapat pada salah satu keping kapasitor.



gambar 1

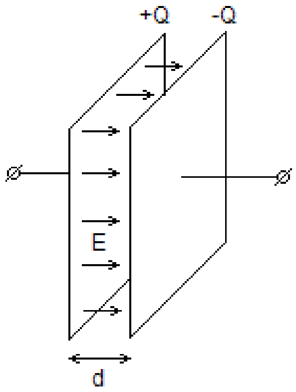
Q=C. V................................. (1)

Q : besar muatan yang tersimpan dalam kapasitor (coulomb)

C : kapasitansi kapasitor (farad)

V : beda potensial pada kapasiotr (volt)

Kapasitor plat sejajar adalah salah satu bentuk kapasitor yang terdiri atas dua plat sejajar yang terpisah pada jarak d yang relatif kecil, dan masing-masing plat memiliki luas penampang A. Bila kedua keping tersebut mempunyai beda potensial V maka diantara kedua keping terdapat medan listrik E.



Gambar 2

Berdasarkan hukum Gauss besar kuat medan listrik diantara kedua plat sejajar:

$E = \frac{Q}{A\varepsilon_o}$ atau

$Q = \varepsilon_o AE$ .... (2)

Bila diantara kedua plat terdapat bahan dielektrik:

$Q = \varepsilon AE$ .... (3)

Berdasarkan Persamaan (1) dan (3), dengan E = V/d maka diperoleh kapasitansi kapasitor:

$$C = \frac{\varepsilon A}{d} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

ε_o : permitivitas ruang hampa (= $\frac{10^{-9}}{36\pi}$ C^2/Nm).

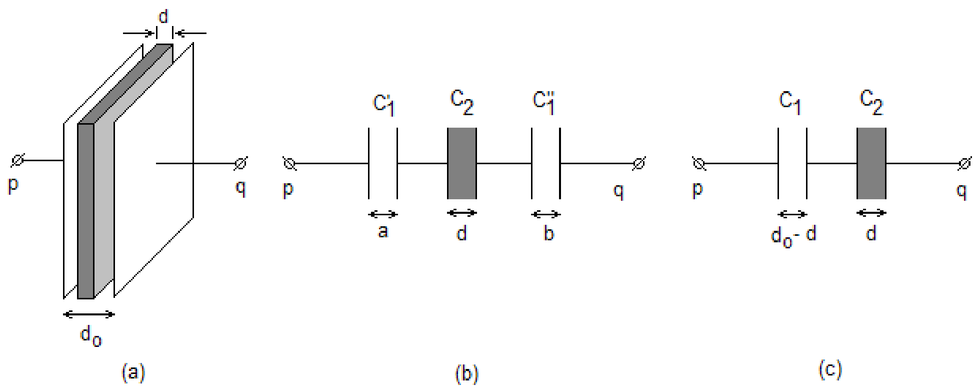
ε : permitivitas bahan dielektrik.

Hubungan antara permitivitas bahan dielektrik dan permitivitas ruang hampa:

$$\varepsilon = \varepsilon_r \, \varepsilon_o \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

ε_r merupakan permitivitas relatif bahan dielektrik yang besarnya bergantung pada jenis bahan dielektrik, untuk ruang hampa $\varepsilon_r = 1$.

Suatu kapasitor plat sejajar dengan luas penampang A dan berjarak d, disisipi oleh bahan dielektrik dengan luas penampang yang sama A dan mempunyai ketebalan t. Kapasitor tersebut indentik dengan kapasitor yang tesusun seri.



Gambar 3

Masing-masing kapasitor pada susunan seri akan mempunyai muatan yang sama (Q_1 = Q_2). Pada Gambar 3c, Berdasarkan Persamaan (4) dan (5) diperoleh besar kapasitas kapasitor susunan seri tersebut:

$$C_{pq} = \frac{\varepsilon_r \varepsilon_o A}{\varepsilon_r (d-t) + d} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Berdasarkan Persamaan (1) : (2) dan (6) diperoleh:

$$C_{pq} = \frac{Q}{V_{pq}}$$, dengan Q = Q_1 = Q_2

$$\frac{\varepsilon_r \varepsilon_O A}{\varepsilon_r (d-t) + d} = \frac{\varepsilon_O A\, E_1}{V_{pq}}$$

$$\varepsilon_r = \frac{E_1 d}{V_{pq} - E_1 (d-t)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

Berdasarkan persamaan (3) dan persamaan (4) diperoleh rumus konstanta dielektrik ada udara:

$Q = \varepsilon_O A\, E$, dengan Q = C V

$$C\,V = \varepsilon_O A\, E$$

$$\frac{\varepsilon_O \varepsilon_r A}{E} V = \varepsilon_O A\, E$$

$$\varepsilon_r = \frac{Ed}{V} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

ε_r : permitivitas relatif suatu bahan.

E_1 : medan listrik pada kapasitor C_1 (hampa udara) (volt/ meter)

V_{pq}: beda potensial antara dua plat kapasitor (volt)

d : jarak antara dua plat kapasitor (meter)

t : tebal bahan dielektrik (meter)

III. PERTANYAAN AWAL

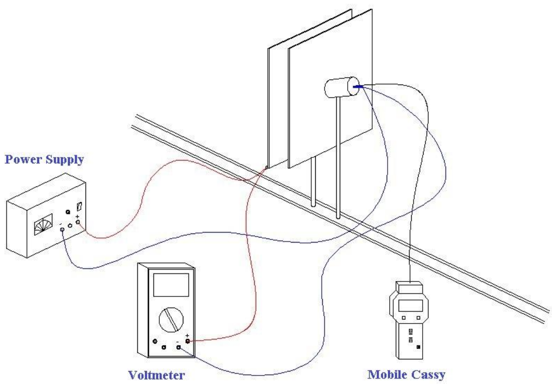
1. Tunjukkan bahwa gabungan antara kapasitor $C_1^{'}$ dan $C_1^{''}$ adalah kapasitor C_1.
2. Buktikan Persamaan (4), (5), (6), dan (7) !

IV. ALAT-ALAT YANG DIBUTUHKAN

1. Plat aluminium
2. Bangku optik
3. *Power supply*
4. *Mobile cassy*
5. *Electric Field Meter*
6. Kabel penghubung
7. Penggaris
8. Jangka sorong
9. Plat plastik
10. Plat kaca
11. Batang statip kayu
12. Voltmeter
13. Pengaman plat

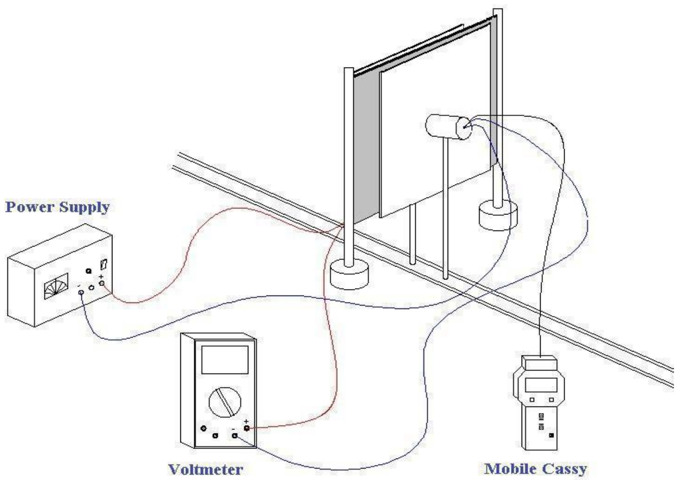
V. PELAKSANAAN PERCOBAAN DAN PENGAMATAN

1. Siapkan alat-alat yang akan digunakan pada percobaan ini.
2. Susun alat-alat seperti pada Gambar 4, dan pastikan agar kedua plat tepat



Gambar 4. Rangkaian percobaan tanpa bahan dielektrik

3. Ukur jarak antara kedua plat (d) dengan menggunakan jangka sorong.
4. Nyalakan power supply dan putar pelan-pelan tombol pengatur tegangan sehingga menunjukkan tegangan tertentu, lalu catat besar tegangan tersebut (V) dan kuat medan listriknya (E).
5. Ulangi percobaan nomor 4 masing-masing untuk 4 tegangan yang berbeda.
6. Tanpa merubah jarak antar plat (d), putar tombol power supply hingga menunjukkan angka nol, lalu matikan power supply tersebut.
7. Ukur tebal plat plastik (t) yang akan digunakan sebagai bahan dielektrik dengan menggunakan jangka sorong, lalu sisipkan diantara kedua plat (tanpa menyentuh kedua plat tersebut) dengan menggunakan statip kayu seperti pada gambar 5.



Gambar 5. Rangkaian percobaan dengan bahan dielektrik

8. Nyalakan power supply dan putar pelan-pelan tombol pengatur tegangan sehingga menunjukkan tegangan tertentu, lalu catat besar tegangan (V) dan kuat medan listriknya (E)
9. Ulangi percobaan nomor 9 masing-masing untuk 4 tegangan yang berbeda.
10. Putar tombol power supply hingga menunjukkan angka nol, lalu matikan power supply tersebut.
11. Ulangi percobaan nomor 7 sampai dengan nomor 10 dengan menggunakan plat kaca sebagai bahan dielektriknya.
12. Putar tombol power supply hingga menunjukkan angka nol, lalu matikan power supply tersebut.
13. Catat nilai skala terkecil (nst) alat ukur yang digunakan pada percobaan ini.

VI. PERHITUNGAN UNTUK MENCAPAI TUJUAN

1. Tentukan nilai konstanta dielektrik dari udara dengan menggunakan persamaan (8)
   disertai dengan kesalahan mutlak, kesalahan relatif, keseksamaan dan harga sebenarnya.
2. Tentukan nilai konstanta dielektrik dari bahan dielektrik plastik dan kaca dengan menggunakan persamaan (7) disertai dengan kesalahan mutlak, kesalahan relatif, keseksamaan dan harga sebenarnya.
3. Bahas sumber – sumber kesalahan yang mungkin terjadi pada percobaan ini.
4. Kesimpulan apa yang anda peroleh dari hasil perhitungan dan pengamatan pada percobaan ini ?

VII. PERTANYAAN AKHIR DAN SOAL

1. Sebuah kapasitor plat sejajar diisi penuh bahan plastik yang memiliki konstanta dielektrik 2,3. Luas setiap plat tersebut adalah 400 cm^2 , dan tebal plastik adalah 0,3 mm. Hitunglah kapasitansi dari kapasitor tersebut!
2. Suatu kapasitor plat sejajar yang memiliki luas 250 cm^2 dihubungkan ke sumber tegangan 120 volt. Mula –mula kapasitor terpisah dengan jarak 5 mm dalam hampa, kemudian sumber tegangan tersebut diputus dan jaraknya dipersempit $\frac{1}{2}$ kali semula. Tentukanlah :
    a. Kapasitansi kapasitor sebelum dan sesudah diputus
    b. Muatan yang tersimpan dalam masing –masing keping
    c. Intensitas medan listrik pada kapasitor
    d. Beda potensial antara keping setelah jaraknya dipersempit

DAFTAR PUSTAKA:

1. Giancoli, Douglas C. 1999. *Fisika Edisi Kelima Jilid 2*. Jakarta: Erlangga

2. Tipler, Paul. 2001. *Fisika untuk Sains dan Teknik*. (Bambang Soegijono, penerjemah). Jakarta: Penerbit Erlangga.

LABORATORIUM FISIKA **LISTRIK MAGNET DAN ELEKTRONIKA**

UNIVERSITAS KATOLIK WIDYA MANDALA SURABAYA

KAPASITOR PLAT SEJAJAR

	1.	____________	NRP	____________
NAMA MAHASISWA :	2.	____________	NRP	____________
	3.	____________	NRP	____________

GROUP / KELOMPOK : ____________

HARI / TGL. PRAKTIKUM ____________ :

TANDA TANGAN : Mahasiswa. ____________ Asisten, ____________

LEMBAR KERJA MAHASISWA

d = …………….m

1. Untuk Udara

No	V (Volt)	E (kV/m)
1		
2		
3		
4		
5		

2. Untuk Bahan Dielektrik Plastik
   t =……………….m

No	V (Volt)	E (kV/m)
1		
2		
3		
4		
5		

3. Untuk Bahan Dielektrik Kaca
   t =………………m

No	V (Volt)	E (kV/m)
1		
2		
3		
4		
5		

Nst alat ukur :

LAMPIRAN V

Angket Modul Petunjuk Praktikum

ANGKET

MODUL PRAKTIKUM KAPASITOR PLAT SEJAJAR

Setelah Anda melakukan percobaan dengan menggunakan modul petunjuk praktikum ini, saya mohon Anda berkenan melengkapi pernyataan berikut dengan memberi tanda centang (√) pada :

SS = Jika anda SANGAT SETUJU

S = Jika anda SETUJU

TS = Jika anda TIDAK SETUJU

STS = Jika anda SANGAT TIDAK SETUJU

NO	PERNYATAAN	PILIHAN			
		SS	S	TS	STS
1	Modul mudah untuk dibaca dan dimengerti				
2	Teori mudahdipahami dan sesuai dengan tujuan percobaan				
3	Alat – alat yang digunakan sesuai dengan kondisi saat percobaan				
4	Tepat digunakan sebagai penunjang dalam praktikum kapasitor plat sejajar				
5	Mengerti jalannya praktikum setelah membaca modul				
6	Dapat melakukan percobaan dengan membaca prosedur percobaan pada modul				
7	Perhitungan untuk mencapai tujuan sudah sesuai dan runtut				
8	Dengan adanya modul membuat bingung dalam melakukan praktikum				

Tulis komentar anda tentang modul petunjuk praktikum tersebut

____

____

LAMPIRAN VI

Petunjuk Penggunaan Alat Kapasitor Plat Sejajar dari LD Didactic Gmbh

Measuring the electric field strength inside a plate capacitor as a function of the dielectrics

Objects of the experiments

- To determine the electrical field strength E for various dielectrics at a constant voltage U
- To determine the electrical field strength E for various dielectrics at a constant charge Q

Principles

The simplest form of capacitor is the plate capacitor. If the distance between the plates is significantly less than the dimensions of the plates, the electric field strength between the plates E can be regarded as homogeneous. It is caused by the charges $+Q$ and $-Q$ which are created by connecting a voltage U to the plates (see fig. 1). The electric field strength is the higher the larger the surface charge density Q/A, i.e. the more charge that is present on the plates and the smaller the surface area A of the plates. It also depends on the dielectric constant ε_r of the material between the two plates.

$$E = \frac{Q}{\varepsilon_0 \cdot \varepsilon_r \cdot A} \quad \text{(I)}$$

The dielectric constant ε_r describes the increase in capacitance by introducing the material $C = Q/U = \frac{\varepsilon_0 \varepsilon_r A}{d}$ of the plate capacitor compared to the vacuum value.

Alternatively the electric field strength E can be determined from the applied voltage U and the distance d between the plates:

$$E = \frac{U}{d} \quad \text{(II)}$$

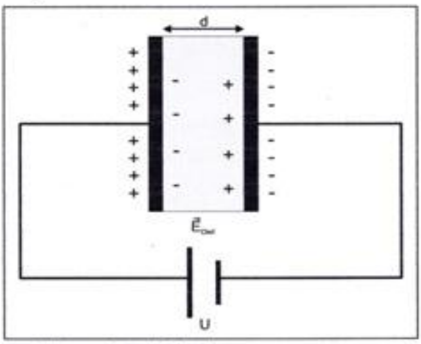


Fig. 1: Plate capacitor with dielectric

Fig. 2: Experimental setup

With a constant charge Q (capacitor plates separated from the voltage supply) the introduction of a dielectric with $\varepsilon_r > 1$ results in a reduction of the electric field E between the capacitor plates. The capacitor field causes a polarisation in the dielectric and therefore an opposing field which causes a resulting smaller field.

When the voltage U remains constant the electric field strength E does not change if a dielectric is introduced between the capacitor plates. The necessary additional charge for the increase of the capacitance is supplied by the voltage supply.

If the dielectric does not completely fill the space between the capacitor plates the electric field strengths differ in the regions with dielectric compared to those without dielectric (see fig. 3). The field strength E_0 in the regions without dielectric is given by the equation (I) with $\varepsilon_r = 1$, the field strength E_r in the regions with dielectric is given by the equation (I) with the dielectric constant ε_r of the dielectric used. The charge Q on the capacitor plates for a connected voltage U is given by: $Q = C_{gesamt} \cdot U$ with the capacitance C_{total} of the capacitor with the dielectric.

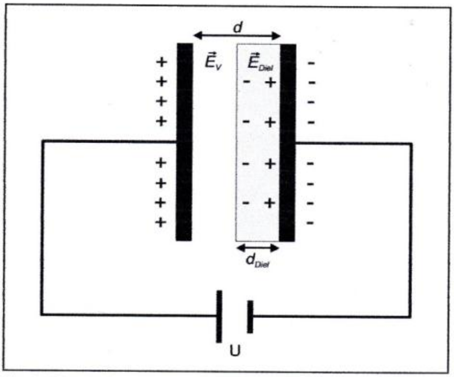


Fig. 3: Electric field in the plate capacitor with dielectric of the thickness $d_{diel} < d$

For calculation of the capacitance of the capacitor with the dielectric all regions must be viewed separately. Here the dielectric has the same surface area A as the plate capacitor, the thickness d_{diel} of the dielectric is however less than the distance d between the plates (see fig. 3) and this allows us to think of the areas with and without dielectric as a series connection of two capacitors with the plate distances d_{diel} and $d - d_{diel}$. The capacitance of the capacitor with the dielectric can be calculated from the formula below:

$$\frac{1}{C_{gesamt}} = \frac{1}{C_{Diel}} + \frac{1}{C_{Luft}} = \frac{d_{Diel}}{\varepsilon_0 \varepsilon_r A} + \frac{d - d_{Diel}}{\varepsilon_0 A} \quad \text{(IV)}$$

When measuring with the electric field meter S, because of the measuring principle it is the field strength in air that is determined; the space between the plates can never be entirely filled with the dielectric.

If the voltage U remains constant, the electric field strength E does not change if a dielectric is introduced between the capacitor plates. The charge necessary for this is supplied by the voltage supply. In the area filled with air, however, the additional charge will result in a higher field strength, which is measured with the electric field meter. The increase in the measured field strength is therefore a direct measure of the increase in charge on the capacitor plates.

With a constant charge Q (capacitor plates separated from the voltage supply) the introduction in a dielectric with $\varepsilon_r > 1$ results in a reduction of the electric field E in the region with the dielectric and therefore also of the average field strength between the capacitor plates. The electric field strength in the areas with air (e.g. also at the location of the electric field meter) will however remain unchanged.

In the experiment, the influence of the dielectric constant ε_r on the field strength is determined. For this purpose, initially at a constant voltage U, a dielectric (glass, plastic) is inserted between the plates and the electric field strength is determined. Then the charged plate capacitor is first separated from the voltage supply and the dielectric is introduced and the electric field strength is measured. From the change in the field strength on introducing the dielectric, the capacitance of the capacitor with the dielectric and the dielectric constant ε_r of the introduced material is determined.

Apparatus

1 electric field meter S	524 080
1 set of accessories for the electric field meter S	540 540
1 universal measuring instrument P	531 835
1 cut-off switch	504 451
1 power supply 450 V	522 27
1 multimeter LDanalog 20	531 120
2 clamp riders with clamp 45/35	460 312
1 optical bench, S1 profile, 50 cm	460 317
3 safety connection leads, 50 cm, red	500 421
1 safety connection lead, 50 cm, blue	500 422
1 safety connection lead, 100 cm, blue	500 442

Note:

For carrying out this experiment, as an alternative to the universal measuring instrument P the following can be used:

1 mobile CASSY (524 009)

or

1 Sensor-CASSY (524 010USB) + CASSY Lab (524 200)) / CASSY-Display (524 020)

or

1 Pocket CASSY (524 009) + CASSY Lab (524 200)

Alternatively, instead of the power supply 450 V (522 27) and the multimeter LDanalog 20 (531 1200), the 10 kV high power supply (521 70) can be used. When carrying out the experiment with the 10 kV high voltage power supply, the maximum voltage of 300 V must **not** be exceeded because the cut-off switch cannot be loaded any higher!

Introductory remark

The glass plates and plastic plates used as the dielectric can easily be charged electrostatically. For this reason the plates should be discharged before the experiment, e.g. by rinsing the surfaces with running water (and, if applicable, washing up liquid) and dried in air. The surfaces must not be rubbed to dry them because that would again lead to electrostatic charging!

For the distance between the capacitor plate and the electric field meter S, which is decisive for the size for the electric field, 1 mm must be added. The measuring electrodes in the electric field meter are located 1 mm behind the capacitor plate which is used in the electric field meter. This is due to the construction of the meter.

Setup

The experimental setup is shown in fig. 2. For the setup the following steps are required:

- Fix one of the capacitor plates with a stand base onto the stand rod made from plastic and attach it using an optical rider with clamp onto the optical bench profile S1.
- Push the drilled capacitor plate onto the electric field meter S. Attach it also onto the optical bench profile S1 by means of an optics rider with clamp.
- Connect the electric field meter to the universal measuring instrument P.
- Connect the negative pole of the 450 V to the earthing socket on the back of the electric field meter.
- Connect the positive pole of the 450 V power supply to the cut-off switch.

- Connect the second output of the cut-off switch to the free capacitor plate. The connection cable should be suspended freely so that no surfaces (e.g. table top) are touched.
- Connect the multimeter LDanalog 20 for measuring the voltage to the output of the 450 V power supply.
- Set the distance between the plates to d = 9 mm. Ensure that the plates are aligned as parallel as possible.

Warning

It is absolutely necessary to provide correct earthing of the electric field meter S. Because typically the measurement is made using a high voltage, the electric field meter S must never be operated without the 4 mm socket on the back being connected to ground.

Carrying out the experiment

a) Measuring with constant voltage

- Increase the voltage on the capacitor plates step by step to 300 V and read the value of the electric field strength E. Then reduce the voltage to zero.
- Carefully insert the glass plate fully between the capacitor plates without changing the distance between the capacitor plates. Make sure the capacitor plates do not make contact with the glass plate because that might lead to the charging up of the glass plate, which would falsify the measuring result.
- Read the value of the electric field E for the voltage U = 0 V. If the value of the electric field is not equal to zero the plate is charged electrostatically and must be discharged (see introductory note).
- Increase the voltage on the capacitor plates step by step to 300 V and read the value of the electric field strength E. Then reduce the voltage to zero.
- Repeat the experiment using the plastic plate.

b) Measuring with constant charge

- Increase the distance between the capacitor plates to 19 mm.
- Increase the voltage on the capacitor without the dielectric to 200 V and read the value of the electric field strength E.
- Using the cut-off switch, separate the capacitor from the voltage source and read the value of the electric field strength E. If the field strength continuously falls, the charge leaks away from the capacitor plate. In this case it must be checked if the cable between the switch and the capacitor plate has contact with any other surface (e.g. the table top). If this is not the case, the stand rod used for attaching the plate must be cleaned (finally rinse with distilled water) because a conducting coating has formed on the surface.
- Reduce the voltage to zero and carefully insert the glass plate between the capacitor plates. The value of the electric field should be equal to zero (see above)
- Increase the voltage to 200 V and read the value for the electric field strength E_{glass}'.
- Separate the capacitor from the voltage supply by means of the cut-off switch. Check the value of the electric field strength.
- Carefully remove the glass plate from the capacitor without changing the distance between the capacitor plates or making contact with the capacitor plates.
- Read the value of the electric field strength E_Q.
- Using the cut-off switch reconnect the capacitor to the voltage source and read the electric field strength E_U.
- Repeat the experiment using the plastic plate.

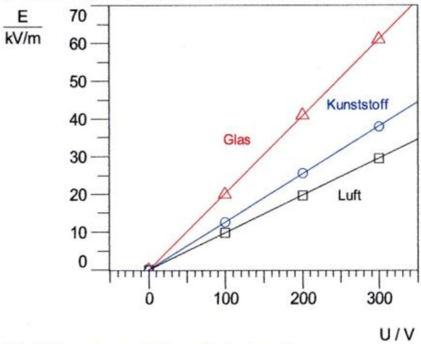
Measuring example and evaluation

a) Measuring with constant voltage

In table 1 the measuring results for an example of a measurement of the electric field strength E_{air} without the dielectric is shown, E_{glass} with the glass plate and $E_{plastic}$ as a function of the voltage U and they are plotted in fig. 4.

The linear dependency of the field strength E on the applied voltage U can be clearly observed, with the electric field strength rising most rapidly for glass.

U / V	E_{air} / kV/m	E_{glass} / kV/m	$E_{plastic}$ / kV/m
0	0	0	0
100	9.9	20.0	12.7
200	19.7	41.0	25.7
300	29.5	61.0	38.0



Tab. 1: Measuring results for constant voltage U

Fig. 4: The electric field strength E in a capacitor as a function of the applied voltage U without and with dielectric (glass, plastic)

As described in the introduction, the increase in the electric field strength on introducing the dielectric into the capacitor exactly mirrors the increase in the charge Q on the capacitor plates. It can be calculated using the formula $Q = \varepsilon_0 \cdot A \cdot E$ (see equation (I)). The values for Q obtained by inserting the measured values from table 1 for U = 300 V are listed in table 2. Using the equation $C_{total} = Q/U$ one obtains the total capacitance of the capacitor with the dielectric (table 2).

By solving the equation (IV) and inserting the values from table 2 one obtains the dielectric constant ε_r for the materials used:

$$\varepsilon_r = \frac{C_g \cdot d_{Diel}}{\varepsilon_0 A - C_g (d - d_{Diel})}$$

For the thickness of the dielectric, for air the plate distance d = 10 mm was used (see introductory note). The thickness of the glass plate was d_{glass} = 6 mm and the thickness of the plastic plate $d_{plastic}$ = 4 mm.

The value for the dielectric constant ε_r for air, plastic and glass correspond well to the literature value for air of ε_r = 1.0, for glass ε_r = 6 – 8 and polystyrene, the plastic used, ε_r = 2.5 .

Material	E_{air} / kV/m	Q / nC	C_{total} / pF	ε_r
Air	29.5	20.5	68.3	0.98
Plastic	38.0	26.4	87.9	2.1
Glass	61.0	42.3	141	6.5

Tab. 2: Results for the charge Q, the total capacitance C_{total} and the dielectric constant ε_r for various dielectrics

b) Measuring with constant charge

In the example measurement, the capacitor was charged without the dielectric to 200 V and then separated from the voltage supply. Over several minutes no reduction in the voltage was observed.

Then measurements were carried out for the glass plate and the plastic plate with the constant charge. The measured values are listed in table 3. The field strengths E' were measured with the dielectric, the field strengths E_Q after removing the dielectric while the voltage supply was still not connected and the field strengths E_U after the voltage supply had been reconnected.

The field strengths E' are different for plastic and glass on account of their dielectric constants, which had been investigated in more detail in section a. On account of the larger distance between the plates, the measured values are smaller than in section a.

Because the field strengths in the experimental setup used are always measured in air, whether or not a dielectric is also used, the measured values do not differ when the charge on the plate remains constant. The small change for plastic indicates that the plastic plate was slightly charged which falsified the measured result.

If the capacitor is then connected to the voltage supply, the charge flows off the capacitor plates and the measured field is smaller. The values are independent of the material located in the capacitor at the start because the electric field strength depends only on the applied voltage and the distance between the plates.

Material	E' / kV/m	E_Q / kV/m	E_U / kV/m
Plastic	9.3	10	8.7
Glass	12	12	8.8

Tab. 3: Measured values with constant charge