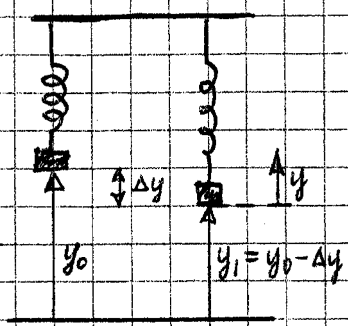
Oppgave 1



a) $mg = k\Delta y$

$$\Delta y = \frac{mg}{k} = \frac{0{,}2 \cdot 9{,}81}{30}\,m = \underline{0{,}065\,m}$$

b) Vi bruker likevektsposisjonen y_1 som utgangspunkt for y

$$ma + ky = 0$$

$$m\frac{d^2y}{dt^2} + ky = 0$$

Prøver løsning $y(t) = A\sin(\omega t + \delta)$

$$\frac{dy}{dt} = \omega A\cos(\omega t + \delta) \qquad \frac{d^2y}{dt^2} = -\omega^2 A\sin(\omega t + \delta)$$

$$m(-\omega^2 A\sin(\omega t + \delta)) + kA\sin(\omega t + \delta) = 0$$

$-m\omega^2 + k = 0 \Rightarrow \omega = \sqrt{k/m}$ gir løsning

$\Rightarrow \underline{y(t) = A\sin(\omega t + \delta) \text{ med } \omega = \sqrt{k/m} \text{ beskriver svingningene}}$

c) $f = \omega/2\pi = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi}\sqrt{\frac{30}{0{,}2}}\,Hz = \underline{1{,}95\,Hz}$

$T = 1/f = 1/1{,}95\,s = \underline{0{,}51\,s}$

$\omega = \sqrt{k/m} = \sqrt{30/0{,}2}\,s^{-1} = 12{,}25\,s^{-1}$

d) I øvre stilling (y_0) er hastigheten $v = 0$, og fjæren er hverken strukket eller sammenpresset

$\Rightarrow E_{tot} = mg(y_1 + \Delta y) = 0{,}2 \cdot 9{,}81 \cdot (1 + 0{,}065)\,J = \underline{2{,}09\,J}$

Amplituden $A = \Delta y = \underline{0{,}065\,m}$

e) $t_0 = 0\,s \quad y = 0{,}065\,m \quad v_0 = 0\,m/s$

f) $a = \frac{d^2y}{dt^2} = -\omega^2 A\sin(\omega t + \pi/2)$

$a_{max} = \pm\omega^2 A = \pm\frac{k}{m}A = \pm\frac{30}{0{,}2}\cdot 0{,}065\,m/s^2 = \underline{\pm 9{,}81\,m/s^2}$

$= \pm\frac{k}{m}\Delta y = \pm\frac{k}{m}\cdot\frac{mg}{k} = \underline{\pm g}$

Oppgave 2.

a) Egnet Gaussflate: Sylinder med lengde l

$0 < r < R_1$: Omsluttet ladning: $Q = \pi r^2 l \cdot \rho$

$$\int \bar{E}\, d\bar{A} = E \cdot 2\pi r l = \frac{Q}{\varepsilon_0} = \frac{\pi r^2 l \rho}{\varepsilon_0}$$

$$\underline{E = \frac{\rho r}{2\varepsilon_0}}$$

b) $R_1 < r < R_2$: Omsluttet ladning: $Q = \pi R_1^2 l \rho$

$$\int \bar{E}\, d\bar{A} = E \cdot 2\pi r l = \frac{Q}{\varepsilon_0} = \frac{\pi R_1^2 l \rho}{\varepsilon_0}$$

$$\underline{E = \frac{\rho R_1^2}{2\varepsilon_0 r}}$$

c) $R_2 < R < R_3$: Omsluttet ladning: $Q = \pi R_1^2 l \rho + \pi (r^2 - R_2^2) l \rho$

$$Q = \pi l \rho (R_1^2 + r^2 - R_2^2)$$

$$\int \bar{E}\, d\bar{A} = E \cdot 2\pi r l = \frac{Q}{\varepsilon_0}$$

$$\underline{\underline{E = \frac{\rho (R_1^2 + r^2 - R_2^2)}{2\varepsilon_0 r}}}$$

d) $r > R_3$: Omsluttet ladning: $Q = \pi R_1^2 l \rho + \pi (R_3^2 - R_2^2) l \rho$

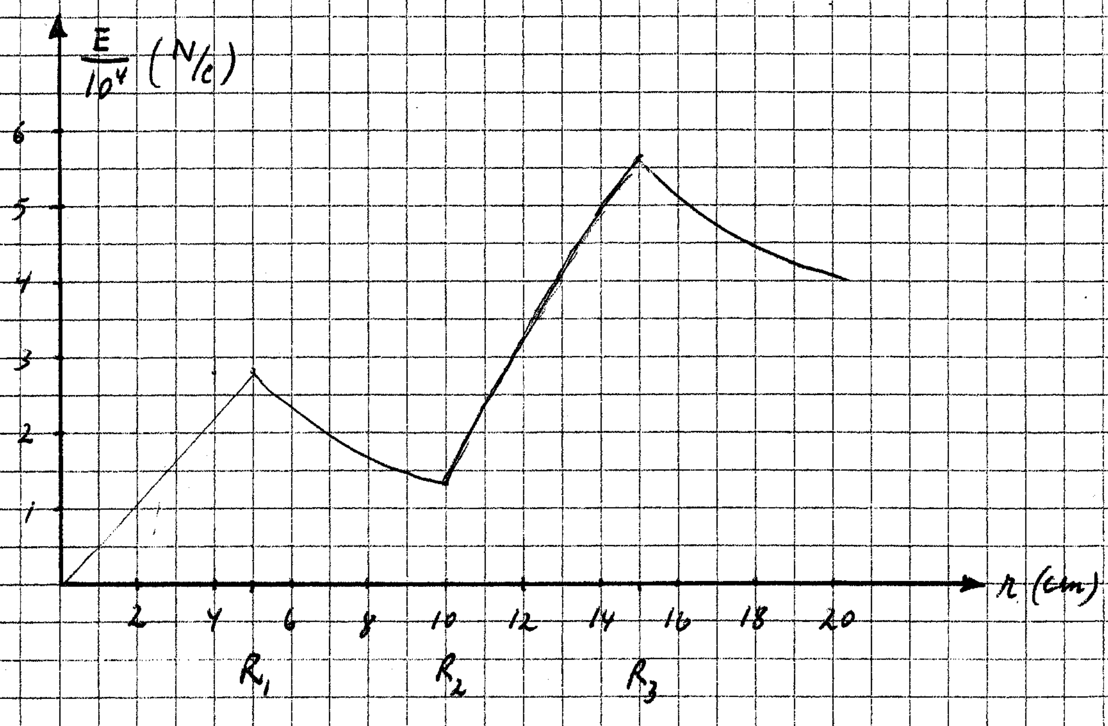
$$\int \bar{E}\, d\bar{A} = E \cdot 2\pi r l = \frac{Q}{\varepsilon_0} = \frac{\pi l \rho (R_1^2 + R_3^2 - R_2^2)}{\varepsilon_0}$$

$$E = \frac{\rho (R_1^2 + R_3^2 - R_2^2)}{2\varepsilon_0 r}$$

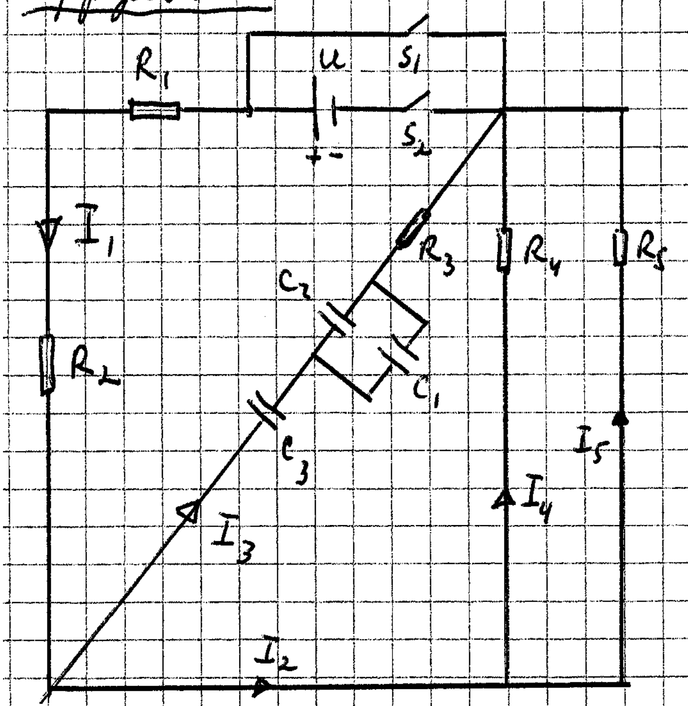
Oppgave 2 forts.

e)

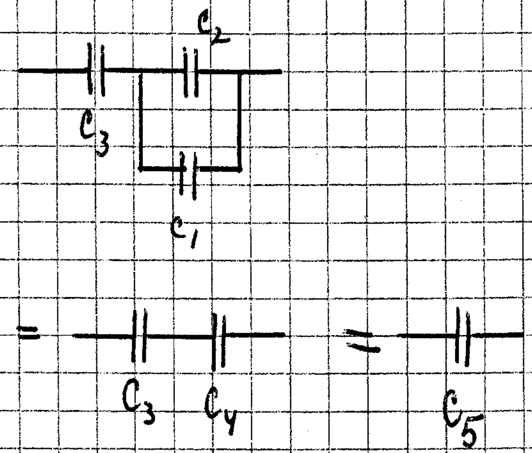
r	E
$0 < r < R_1$	$\propto r$
R_1	$\frac{\rho R_1}{2\varepsilon_0} = 2.82 \cdot 10^4$ N/C
$R_1 < r < R_2$	$\propto 1/r$
R_2	$\frac{\rho R_1}{4\varepsilon_0} = 1.41 \cdot 10^4$ N/C
$R_2 < r < R_3$	$\frac{\rho(r^2 - 3R_1^2)}{2\varepsilon_0 r}$
R_3	$\frac{\rho R_1}{\varepsilon_0} = 5.65 \cdot 10^4$ N/C
$> R_3$	$\propto 1/r$



Oppgave 3.



a) Vi ser på kondensator-koblingen



$C_4 = C_1 + C_2 = (1+2)\,\mu F = 3\,\mu F$

$C_5 = \frac{C_3 \cdot C_4}{C_3 + C_4} = \frac{3 \cdot 3}{3+3}\,\mu F \qquad = \underline{1{,}5\,\mu F}$

b) Når kondensatorane er fullt oppladet, er $I_3 = \underline{0}$

Parallellkoblingen av R_4 og R_5 har ekvivalentmotstand

$R_6 = \frac{R_4 \cdot R_5}{R_4 + R_5} = \frac{40 \cdot 50}{40+50}\,\Omega = 22{,}2\,\Omega$

$I_1 = I_2 = \frac{U}{R_6 + R_1 + R_2} = \frac{12{,}0}{22{,}2+10+20}\,A \qquad = \underline{0{,}23\,A}$

$I_4 = I_2 \cdot \frac{R_6}{R_4} = 0{,}23 \cdot \frac{22{,}2}{40}\,A \qquad = \underline{0{,}13\,A}$

$I_5 = I_2 - I_4 = (0{,}23 - 0{,}13)\,A \qquad = \underline{0{,}10\,A}$

Retningen som vist i figuren.

c) Spenningen over kondensatorkoblingen er lik spenningen over R_6: $V_6 = I_2 \cdot R_6 = 0{,}23 \cdot 22{,}2\,V = 5{,}1\,V$

$Q_5 = C_5 V_6 = 1{,}5 \cdot 10^{-6} \cdot 5{,}2\,C \quad = 7{,}7\,\mu C$

$Q_3 = Q_4 = Q_5 = 7{,}7\,\mu C \qquad = \underline{7{,}7\,\mu C}$

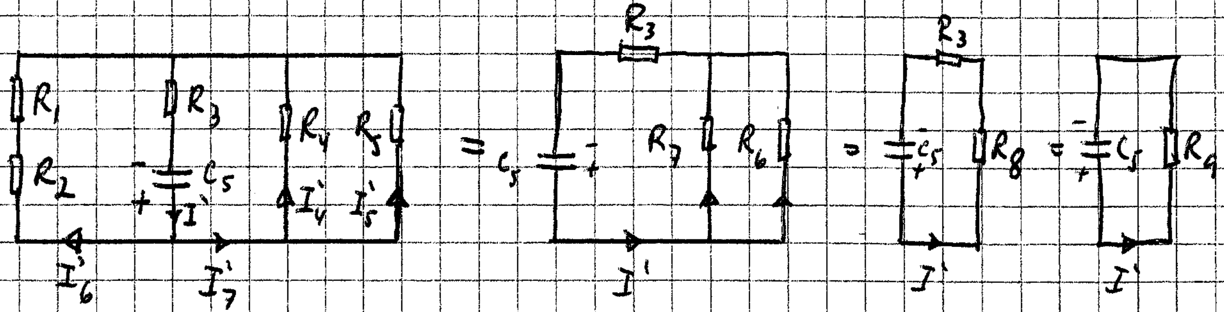
c) forts.

Spenningen over C_4 er $V_4 = \frac{Q_4}{C_4} = \frac{7.8 \cdot 10^{-6}}{3 \cdot 10^{-6}} V = 2.6 V$

$Q_1 = V_4 \cdot C_1 = 2.6 \cdot 1 \cdot 10^{-6} C \qquad = \underline{\underline{2.6 \mu C}}$

$Q_2 = V_4 \cdot C_2 = 2.6 \cdot 2 \cdot 10^{-6} C \qquad = \underline{\underline{5.2 \mu C}}$

d) Kretsen kan nå ekvivaleres med



$R_7 = R_1 + R_2 = (10+20)\Omega = 30\Omega$

$R_8 = \frac{R_7 \cdot R_6}{R_7 + R_6} = \frac{30 \cdot 22.2}{30 + 22.2}\Omega = 12.8\Omega$

$R_9 = R_3 + R_8 = (30 + 12.8)\Omega = 42.8\Omega$

$\frac{q_5}{C_5} - I' R_9 = 0 \qquad I' = -\frac{dq_5}{dt}$

$\frac{q_5}{C_5} + \frac{dq_5}{dt} R_9 = 0$

$\frac{dq_5}{q_5} = -\frac{dt}{R_9 C_5} \Rightarrow \ln q_5 = -\frac{t}{R_9 C_5} + K$

$q_5 = K \exp(-t/R_9 C_5) \qquad t = 0: q_5 = Q_5 \Rightarrow K = Q_5$

$I' = -\frac{dq_5}{dt} = \frac{Q_5}{R_9 C_5} \exp\left(-\frac{t}{R_9 C_5}\right) = \frac{7.8 \cdot 10^{-6}}{42.8 \cdot 1.5 \cdot 10^{-6}} \exp\left(\frac{-t \cdot 10^{6}}{42.8 \cdot 1.5}\right)$

$I' = \underline{\underline{0.12 \exp\left(-\frac{t \cdot 10^6}{64.2}\right) A}} = I'_3 \qquad t$ målt i sek

$$I_6' = I_1' = I_2' = I' \cdot \frac{R_8}{R_7} = 0{,}12 \cdot \frac{12{,}8}{30} \exp\left(\frac{-t \cdot 10^6}{64{,}2}\right) A$$

$$= \underline{0{,}05 \exp\left(\frac{-t \cdot 10^6}{64{,}2}\right) A}$$

$$I_5' = I' \cdot \frac{R_8}{R_5} = 0{,}12 \cdot \frac{12{,}8}{50} \exp\left(\frac{-t \cdot 10^6}{64{,}2}\right) A \quad = \underline{0{,}03 \exp\left(\frac{-t \cdot 10^6}{64{,}2}\right) A}$$

$$I_4' = I' \cdot \frac{R_8}{R_4} = 0{,}12 \cdot \frac{12{,}8}{40} \exp\left(\frac{-t \cdot 10^6}{64{,}2}\right) A \quad = \underline{0{,}04 \exp\left(\frac{-t \cdot 10^6}{64{,}2}\right) A}$$

Oppgave 4.

a) $f = \underline{25\,\text{cm}}$ fordi billedavstand = fokalavstand ved avbilding av fjernt objekt.

b) $\dfrac{1}{f} = \dfrac{n-1}{1}\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$

$\dfrac{1}{25} = \dfrac{1.5-1}{1}\left(\dfrac{1}{R_1} - \dfrac{1}{(-25)}\right) \Longrightarrow R_1 = \underline{25\,\text{cm}}$

c) $\dfrac{1}{i} + \dfrac{1}{s} = \dfrac{1}{f}$

$\dfrac{1}{i} = \dfrac{1}{f} - \dfrac{1}{s} = \dfrac{1}{25} - \dfrac{1}{100} \Longrightarrow i = \underline{33{,}3\,\text{cm}}$

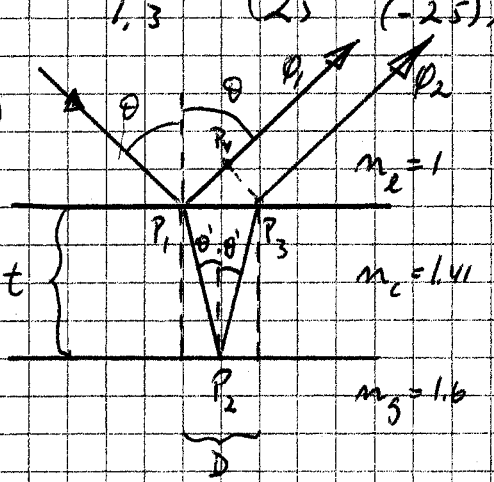
$M = -\dfrac{i}{s} = -\dfrac{33{,}3}{100} = \underline{-\dfrac{1}{3}}$

Bildet er 33,3 cm fra linsen, og på motsatt side av linsen i forhold til objektet. Bildet er forminsket (til $\frac{1}{3}$), omvendt og reelt.

d) $\dfrac{1}{i} + \dfrac{1}{s} = \dfrac{1}{f} = \dfrac{n_2 - n_1}{n_1}\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$

$\dfrac{1}{f} = \dfrac{1.5-1.3}{1.3}\left(\dfrac{1}{25} - \dfrac{1}{(-25)}\right) \Longrightarrow f = \underline{81{,}25\,\text{cm}}$

e)



$1 \cdot \sin 45^\circ = 1.41 \cdot \sin\theta'$

$\Longrightarrow \theta' = \underline{30^\circ}$

$P_1P_4 = l \qquad P_1P_3 = D$

$P_1P_2 = P_2P_3 = d$

$\varphi_1 = \pi + 2\pi \cdot \dfrac{l}{\lambda}$

$\varphi_2 = \pi + 2\pi \cdot \dfrac{2d}{\lambda} \cdot n_c$

$\varphi = \varphi_2 - \varphi_1 = \dfrac{2d n_c \cdot 2\pi}{\lambda} - \dfrac{2\pi l}{\lambda} = \dfrac{2\pi}{\lambda}(2d n_c - l) = m \cdot 2\pi$

$m = 1, 2, 3, \ldots$

Oppg 4 forts

e) forts $\quad 2 d n_c - l = \lambda \cdot m$

$d = \frac{t}{\cos\theta'} \qquad l = D \sin\theta = 2t \cdot \tan\theta' \sin\theta$

$$2 \cdot \frac{t}{\cos\theta'} \cdot n_c - 2t \cdot \tan\theta' \sin\theta = m \cdot \lambda$$

$$t = \frac{\lambda m}{2\left(\frac{n_c}{\cos\theta'} - \frac{\sin\theta' \sin\theta}{\cos\theta'}\right)} = \frac{\lambda m \cos\theta'}{2(n_c - \sin\theta' \sin\theta)}$$

$$t = \frac{\lambda m \cos 30°}{2(1.41 - \sin 30° \sin 45°)} = \underline{0.41 \cdot m \cdot \lambda}$$

Gull lys: $t = m \cdot 0.41 \cdot 585\,nm$

$= \underline{239.9\,nm,\ 479.8\,nm,\ 719.6\,nm \ldots}$

gir konstruktiv interferens