4.1

a) $\bar{T} = \frac{\sum_{i=1}^{N} T_i}{N}$

$= \frac{(54{,}2 + 54{,}0 + 53{,}9 + 54{,}4 + 54{,}6 + 54{,}1 + 54{,}2 + 54{,}0 + 54{,}3 + 53{,}8)\,s}{10}$

$\bar{T} = 54{,}15\,s = 54{,}2\,s$

Største avvik: $54{,}6\,s - 54{,}2\,s = 0{,}4\,s$

$\delta T = 0{,}4\,s$

$\underline{T = 54{,}2\,s \pm 0{,}4\,s}$

b) Tiden for 1 pendelsvingning:

$t = \frac{T}{20} = \frac{(54{,}2 \pm 0{,}4)\,s}{20}$

$\underline{t = (2{,}71 \pm 0{,}02)\,s}$

4.2.1

$a = (3{,}7 \pm 0{,}2)\ m/s^2$

$\vec{V_0} = (1{,}7 \pm 0{,}1)\ \frac{m}{s}$

a) $V(t) = V_0 + at$

$= 1{,}7\ \frac{m}{s} + 3{,}7\ \frac{m}{s^2} \cdot 5{,}05$

$= 20{,}2\ \frac{m}{s}$

$\frac{\delta a}{a} = \frac{0{,}2\ m/s^2}{3{,}7\ m/s^2} = 0{,}0541 = 5\%$

$\frac{\delta t}{t} = \frac{0{,}1\ s}{5{,}05\ s} = 0{,}0200 = 2\%$

$\frac{\delta(at)}{at} = \frac{\delta a}{a} + \frac{\delta t}{t}$

$= 0{,}0541 + 0{,}0200 = 0{,}0741 = 7\%$

$\delta V = \delta V_0 + \delta(at)$

$= 0{,}1\ m/s + 0{,}0741 \cdot (3{,}7\ m/s^2 \cdot 5{,}05\ s)$

$= 1{,}47\ m/s = 1\ m/s$

$V = 20\ \frac{m}{s} \pm 1\ \frac{m}{s}$ $\qquad \frac{\delta V}{V} = 0{,}0728 = 7\%$

b) $s = s_0 + v_0 t + \frac{1}{2} a t^2$

$s_0 = 0$

$s(t = 5{,}0\,s) = v_0 t + \frac{1}{2} a t^2$

$= 1{,}7 \frac{m}{s} \cdot 5{,}0\,m + \frac{1}{2} \cdot 3{,}7\,m/s^2 \cdot (5{,}0\,s)^2$

$s = 54{,}75\,m = 55\,m$

$\delta s = \delta(v_0 t) + \delta\left(\frac{1}{2} a t^2\right)$

$\frac{\delta v_0}{v_0} = \frac{0{,}1 \frac{m}{s}}{1{,}7 \frac{m}{s}} = 0{,}0588 = 6\,\%$

$\frac{\delta(v_0 t)}{v_0 t} = 0{,}0588 + 0{,}0200 = 0{,}0788 = 8\,\%$

$\frac{\delta\left(\frac{1}{2} a t^2\right)}{\frac{1}{2} a t^2} = 0{,}0541 + 0{,}0200 + 0{,}0200 = 0{,}0941 = 9\,\%$

$\delta s = \delta(v_0 t) + \delta\left(\frac{1}{2} a t^2\right)$

$= 0{,}0788 \cdot \left(1{,}7 \frac{m}{s} \cdot 5{,}0\,s\right) + 0{,}0941 \cdot \left(\frac{1}{2} \cdot 3{,}7 \frac{m}{s^2} (5{,}0\,s)^2\right)$

$= 5{,}02\,m = 5\,m$

$\underline{s = 55\,m \pm 5\,m}$ $\qquad \frac{\delta s}{s} = 0{,}0917 = 9\,\%$

c) Bevegelsesligning i oppgave b):

$$s = v_0 t + \frac{1}{2} a t^2$$

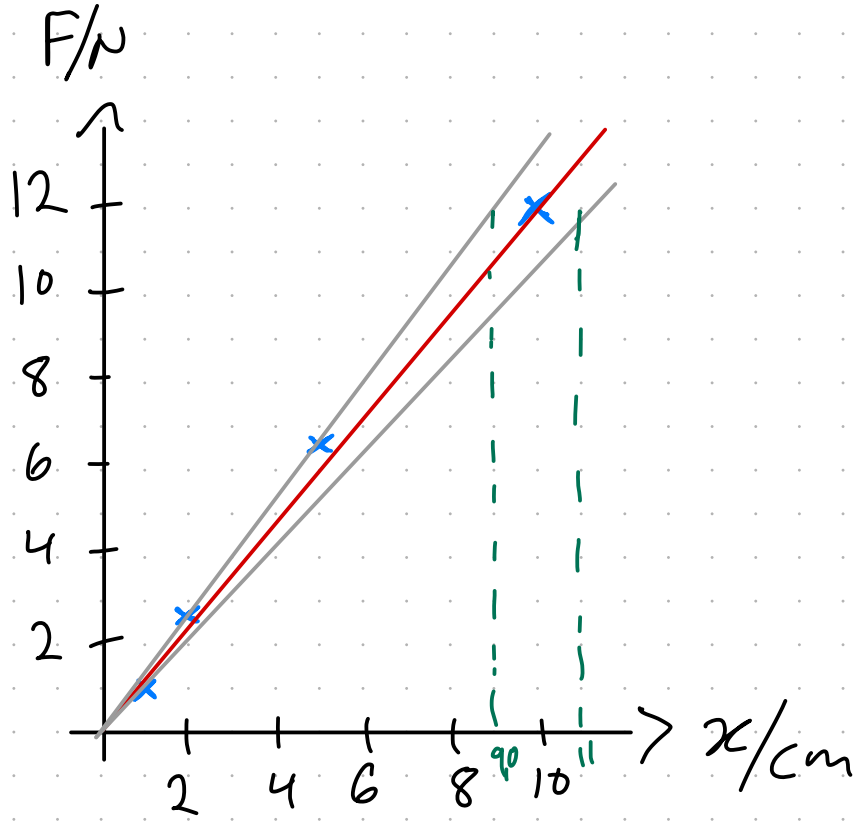
t er en faktor i begge ledd og er i tillegg kvadrert i det andre leddet. Usikkerheten for tiden får derfor dobbel virkning i dette leddet.

4.2.2

a) 3 - 3 - 3 - 4 - 2

b) 1. $2 \cdot 10^4$
2. $2{,}3 \cdot 10^4$
3. $2{,}35 \cdot 10^4$
4. $2{,}346 \cdot 10^4$
5. $2{,}3456 \cdot 10^4$

4.3



Fjærkonstanten k er stigningstallet til den rette grafen: $k = \frac{12\,N}{10\,cm} = \frac{12\,N}{0{,}10\,m} = 120\,\frac{N}{m} = 0{,}12\,\frac{kN}{m}$

De to grå linjene viser usikkerheten. Når $F = 12\,N$, krysser de: 9,0 cm og 11 cm.

$$k_{max} = \frac{12\,N}{9{,}0\,cm} = \frac{12\,N}{0{,}090\,m} = 133\,\frac{N}{m} = 0{,}13\,\frac{kN}{m}$$

$$k_{min} = \frac{12\,N}{11\,cm} = \frac{12\,N}{0{,}11\,m} = 109\,\frac{N}{m} = 0{,}11\,\frac{kN}{m}$$

Største avvik: $133\,\frac{N}{m} - 120\,\frac{N}{m} = 13\,\frac{N}{m}$

$$= 0{,}01\,\frac{kN}{m}$$

$$\underline{k = (0{,}12 \pm 0{,}01)\,\frac{kN}{m}}$$