Sensorveiledning med løsningsforslag i FYS1200 ordinær 2018

Alle delspørsmål i settet vektes likt.

1. Mars I

(a)

$$m_{CO_2} = m_C + 2m_O = 12,01\,\text{u} + 2 \cdot 16,00\,\text{u} = \underline{44,01\,\text{u}}$$

Atommassene er tatt fra det periodiske system.

(b)

$$CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$$
$$CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + O_2$$
$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + O_2$$
$$\underline{6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2}$$

Her balanseres først for hydrogen, så for karbon og så for oksygen.

(c)

$$p_1 = 1,0\,\text{atm}, \quad V = \text{konst.}$$
$$T_1 = (273 + 23)\text{K} = 296\text{K}, \quad \text{T}_2 = (273 - 40)\text{K} = 233\,\text{K}$$
$$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$$
$$\frac{T_2 p_1}{T_1} = p_2$$
$$p_2 = \frac{233\text{K} \cdot 1,0\,\text{atm.}}{296\text{K}} = \underline{0,79\,\text{atm.}}$$

(d)

$$P = 50 \cdot 10^3\,\frac{\text{J}}{\text{s}}$$
$$\Delta E = \Delta m c^2$$
$$Pt = \Delta m c^2$$
$$\Delta m = \frac{Pt}{c^2} = \frac{50 \cdot 10^3\,\frac{\text{J}}{\text{s}} \cdot 24 \cdot 3600\,\text{s}}{(3,00 \cdot 10^8)^2} = \underline{4,8 \cdot 10^{-8}\,\text{kg}}$$

(e)

$$N = N_0 \left(\frac{1}{2}\right)^{t/T}$$

$$37\,\mathrm{g} = 100\,\mathrm{g} \left(\frac{1}{2}\right)^{\mathrm{t/2{,}4 \cdot 10^4 a}}$$

$$0,37 = \left(\frac{1}{2}\right)^{t/2{,}4 \cdot 10^4 \mathrm{a}}$$

$$\log 0,37 = \frac{t}{2,4 \cdot 10^4 \mathrm{a}} \cdot \log\left(\frac{1}{2}\right)$$

$$t = \frac{\log 0,37}{\log\left(\frac{1}{2}\right)} \cdot 2,4 \cdot 10^4 \mathrm{a} = \underline{3,4 \cdot 10^4 \text{år}}$$

(f)

$$\rho_A = 0,020\,\frac{\mathrm{kg}}{\mathrm{m}^3}, \quad \rho_N = 0,013\,\frac{\mathrm{kg}}{\mathrm{m}^3}, \quad m_b = 0,300\,\mathrm{kg}$$

Summen av kreftene ned, nitrogenets og ballonghylsens tyngde, er lik oppdriften som skyldes atmosfæren.

$$\Sigma F = 0$$

$$G_N + G_b = O$$

$$\rho_N g V + m_b g = \rho_A g V$$

$$\rho_N V + m_b = \rho_A V$$

$$m_b = (\rho_A - \rho_N) V$$

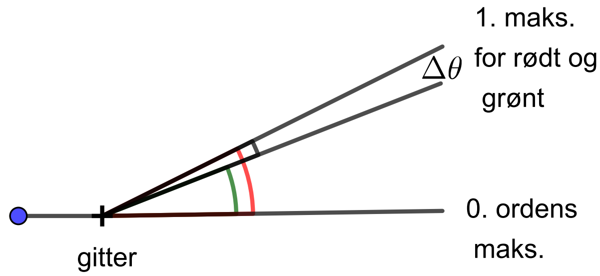
$$\frac{m_b}{(\rho_A - \rho_N)} = V$$

$$V = \frac{0,300\,\mathrm{kg}}{(0,020 - 0,013)\,\frac{\mathrm{kg}}{\mathrm{m}^3}} = 42,85\,\mathrm{m}^3 = \underline{43\,\mathrm{m}^3}$$

2. (a)

$$c = \lambda f$$

$$f = \frac{c}{\lambda} = \frac{3,00 \cdot 10^8\,\frac{\mathrm{m}}{\mathrm{s}}}{3,33\,\mathrm{m}} = \underline{9,01 \cdot 10^7 \mathrm{Hz}}$$



Figur 1: Illustrasjon til oppgave 2 b

(b) $\lambda_r = 700 \cdot 10^{-9}\,\text{m} \quad \lambda_g = 530 \cdot 10^{-9}\,\text{m} \quad d = 2,32 \cdot 10^{-6}\,\text{m}$

$$d \sin\theta_n = n\lambda \quad n = 1$$

$$\sin\theta_r = \frac{\lambda_r}{d} \quad \sin\theta_g = \frac{\lambda_g}{d}$$

$$\theta_r = \sin^{-1}\left(\frac{700 \cdot 10^{-9}\,\text{m}}{2,32 \cdot 10^{-6}\,\text{m}}\right) \quad \theta_r = \sin^{-1}\left(\frac{530 \cdot 10^{-9}\,\text{m}}{2,32 \cdot 10^{-6}\,\text{m}}\right)$$

$$\theta_r = 17,561^\circ \quad \theta_g = 13,205^\circ$$

$$\Delta\theta = \theta_r - \theta_g = 4,356^\circ = \underline{4,36^\circ}$$

(c)

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$1,00 \cdot \sin 63,0^\circ = 1,60 \cdot \sin\theta_2$$

$$\frac{\sin 63,0^\circ}{1,60} = \sin\theta_2$$

$$\theta_2 = 33,840^\circ$$

Vi kaller tykkelsen av platen for L og får:

$$\tan\theta_2 = \frac{x}{L}$$

$$x = L\tan\theta_2$$

$$x = 5,00\,\text{cm}\tan 33,840^\circ = 3,3522\,\text{cm} = \underline{3,35\,\text{cm}}$$

(d) Vi regner først ut lengden l som lyset går gjennom platen ved hjelp av pythagoras setning.

$$l^2 = x^2 + L^2$$

$$l = \sqrt{x^2 + L^2}$$

$$l = \sqrt{3,3522^2 + 5,00^2} \cdot 10^{-2}\,\text{m} = 6,0197 \cdot 10^{-2}\,\text{m}$$

Vi bruker så brytningsindeksen til å finne farten.

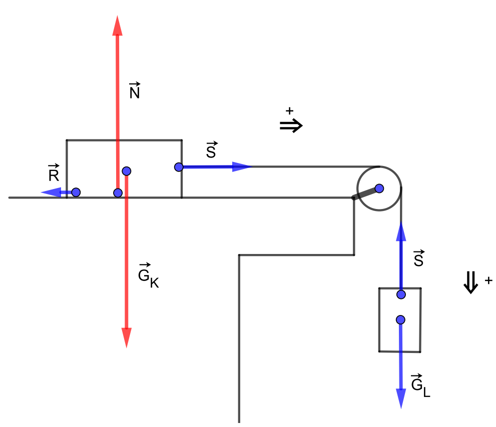
$$n = \frac{c_0}{c} \quad \Rightarrow c = \frac{c_0}{n} = \frac{3,00 \cdot 10^8\,\frac{\text{m}}{\text{s}}}{1,60} = 1,875 \cdot 10^8\,\frac{\text{m}}{\text{s}}$$

Til sist bruker vi formelen for konstant fart.

$$v = \frac{s}{t} \quad \Rightarrow t = \frac{s}{v} = \frac{l}{c}$$

$$t = \frac{6,0197 \cdot 10^{-2}\,\text{m}}{1,875 \cdot 10^8\,\frac{\text{m}}{\text{s}}} = \underline{3,21 \cdot 10^{-10}\,\text{s}}$$

3. (a) Se figur



(b)

$$\mu = 0,20 \quad m_K = 2m_L$$

Her bruker man Newtons 2. lov på systemet som består av loddet og klossen. Snordragene S vil da være indre krefter, og summen av dem blir derfor null.

$$\Sigma F = ma$$

$$G_L - S + S - R = (m_L + 2m_L)a$$

$$m_L g - \mu 2m_L g = 3m_L a$$

$$\frac{m_L(1-2\mu)g}{3m_L} = a$$

$$a = \frac{(1 - 2 \cdot 0,20)}{3} \cdot 9,81\,\frac{\mathrm{m}}{\mathrm{s}^2} = 1,962\,\frac{\mathrm{m}}{\mathrm{s}^2} = \underline{2,0\,\frac{\mathrm{m}}{\mathrm{s}^2}}$$

(c) Her bruker man Newtons 2. lov med klossen som systemet.

$$\Sigma F = m_K a$$

$$S - R = m_K a$$

$$S = \mu m_K g + m_K a$$

$$S = m_K(\mu g + a)$$

$$S = 1,00\,\mathrm{kg}(0,20 \cdot 9,81 + 1,962)\,\frac{\mathrm{m}}{\mathrm{s}^2} = 3,924\,\mathrm{N} = \underline{3,9\,\mathrm{N}}$$

4.

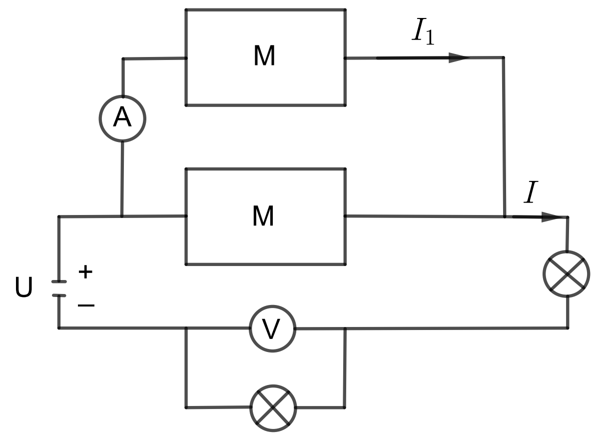
$$I_1 = 0,245\,\mathrm{A} \quad U_l = 6,00\,\mathrm{V} \quad U = 24,00\,\mathrm{V}$$

(a) Motorene er koblet i parallell og har samme spenning. De bruker lik strøm ettersom $U_1 = R_1 I_1$ gir $I_1 = U_1/R_1$ og U og R er like for de to greinene. Total strøm blir dermed $I = 2I_1 = \underline{0,490\,\mathrm{A}}$

(b)

$$P_{tot} = 2P_M = 2UI$$

Lampene er koblet i serie og vil ha like stort spenningsfall hver. Totalt vil de da ha $2 \cdot 6,0\,\mathrm{V} = 12,0\,\mathrm{V}$ spenningsfall. Resten av fallet kommer over motorene. Det vil si $24,00\,\mathrm{V} - 12,00\,\mathrm{V} = 12,00\,\mathrm{V}$ over motorene. $P_{tot} = 2 \cdot 12,00\,\mathrm{V} \cdot 0,245\,\mathrm{A} = \underline{5,88\,\mathrm{W}}$



Figur 2: Figur til oppgave 4

5. Mars II

(a)

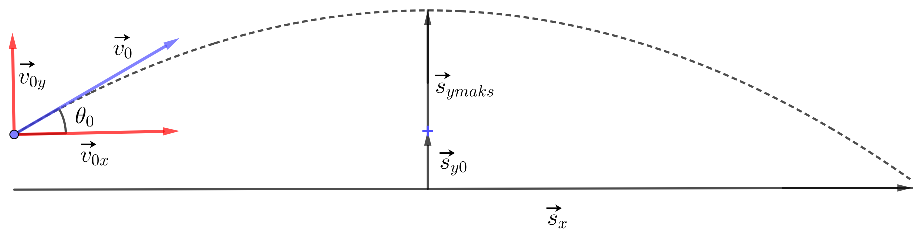
$$v = v_0 + at$$
$$v_0 = v - at$$
$$v_0 = 100\,\frac{\mathrm{m}}{\mathrm{s}} + 18,0\,\frac{\mathrm{m}}{\mathrm{s}^2} \cdot 6,00\,\mathrm{s} = \underline{208\,\frac{\mathrm{m}}{\mathrm{s}}}$$

(b)

$$g = 3,7\,\frac{\mathrm{m}}{\mathrm{s}^2} \quad k = 100\,\frac{\mathrm{N}}{\mathrm{m}} \quad m = 0,025\,\mathrm{kg} \quad x = 0,50\,\mathrm{m}$$
$$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$$
$$v = \sqrt{\frac{k}{m}}x = \sqrt{\frac{100}{0,025}} \cdot 0,50\,\frac{\mathrm{m}}{\mathrm{s}} = 31,62\,\frac{\mathrm{m}}{\mathrm{s}} = \underline{32\,\frac{\mathrm{m}}{\mathrm{s}}}$$

(c)

$$v_0 = 31,6\,\frac{\mathrm{m}}{\mathrm{s}} \quad s_{y0} = 1,50\,\mathrm{m}$$
$$v_{0y} = v_0 \sin\theta_0 = 31,6 \sin 20,0^\circ = 10,807\,\frac{\mathrm{m}}{\mathrm{s}}$$
$$2gs_{ymaks} = v_y^2 - v_{0y}^2 \quad \text{og} \quad v_y = 0 \quad \text{i toppunktet}$$



Figur 3: Figur til oppgave 5c og d

$$2gs_{ymaks} = -v_{0y}^2$$

$$s_{ymaks} = \frac{-v_{0y}^2}{2g} = \frac{-10,807^2}{2(-3,7)}\,\mathrm{m} = 15,78\,\mathrm{m}$$

$$s_{ytotal} = 15,78\,\mathrm{m} + 1,50\,\mathrm{m} = \underline{17\,\mathrm{m}}$$

(d)

$$v_{0x} = v_0 \cos 20,0^\circ = 31,6\,\frac{\mathrm{m}}{\mathrm{s}} \cos 20,0^\circ = 29,694\,\frac{\mathrm{m}}{\mathrm{s}}$$

$$s_y = v_{0y}t + \frac{1}{2}gt^2$$

$$-1,50 = 10,807t - \frac{1}{2} \cdot 3,7t^2$$

$$1,85t^2 - 10,807t - 1,50 = 0$$

$$t = 5,9772 \quad \text{eller} \quad t = -0,1356$$

Det vil si:

$$s_x = v_{0x}t = 29,694\,\frac{\mathrm{m}}{\mathrm{s}} \cdot 5,9772\,\mathrm{s} = 177,48\,\mathrm{m} = \underline{0,18\,\mathrm{km}}$$

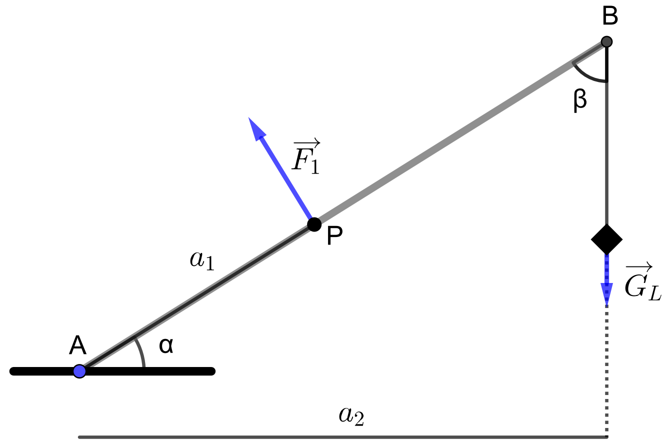
(e)

$$\Sigma M = 0$$

$$F_1 a_1 = G_L a_2$$

$$F_1 a_1 = mgAB \cdot \sin\beta$$

$$F_1 = \frac{10,0\,\mathrm{kg} \cdot 3,7\,\frac{\mathrm{m}}{\mathrm{s}^2} \cdot 0,90\,\mathrm{m} \cdot \sin 57,0^\circ}{0,40\,\mathrm{m}} = 69,81\,\mathrm{N} = \underline{70\,\mathrm{N}}$$



Figur 4: Figur til oppgave 5e

(f) $r = 50,0\,\mathrm{m} \quad a_t = 9,8\,\frac{\mathrm{m}}{\mathrm{s}^2} \quad g = 3,7\,\frac{\mathrm{m}}{\mathrm{s}^2}$

$$a = \frac{4\pi^2 r}{T^2} \quad \Rightarrow \quad T^2 = \frac{4\pi^2 r}{a} \quad \Rightarrow \quad T = \sqrt{\frac{4\pi^2 r}{a}} = 2\pi\sqrt{\frac{r}{a}}$$

$$\Delta T = T_2 - T_1 = 2\pi(\sqrt{\frac{r}{a_2}} - \sqrt{\frac{r}{a_1}}) =$$

$$\Delta T = 2\pi\left(\sqrt{\frac{50,0\,\mathrm{m}}{3,7\,\frac{\mathrm{m}}{\mathrm{s}^2}}} - \sqrt{\frac{50,0\,\mathrm{m}}{9,8\,\frac{\mathrm{m}}{\mathrm{s}^2}}}\right) = \underline{8,9\,\mathrm{s}}$$

Omløpstiden er altså blitt redusert med 8,9 sekunder.