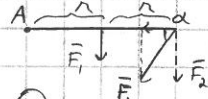
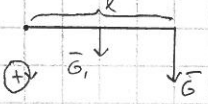
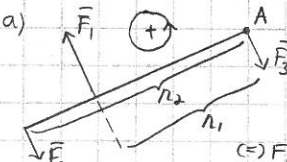


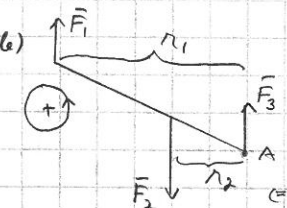
# FY5 Jaksollinen liike ja aallot

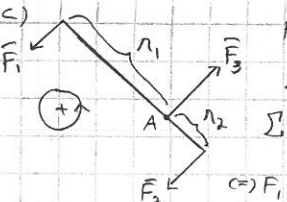
1.6  $M = 130 \text{ Nm}$ ,  $r = 24 \text{ cm}$   
 $M = F \cdot r \Rightarrow F = \frac{M}{r} = \frac{130 \text{ Nm}}{0,24 \text{ m}} = 541,667 \text{ N} \approx 540 \text{ N}$

1.12   $F_1 = 4,0 \text{ N}$ ;  $F_2 = 6,0 \text{ N}$ ;  $r = 11,0 \text{ cm}$   
 a)  $M_1 = F_1 \cdot r = 4,0 \text{ N} \cdot 0,110 \text{ m} = 0,44 \text{ Nm}$   
 b)  $M = F_1 \cdot r + F_2 \cdot 2r = F_1 \cdot r + F_2 \cdot 2r$   
 i)  $\alpha = 90^\circ$ :  $M = 1,76 \text{ Nm} \approx 1,8 \text{ Nm}$   
 ii)  $\alpha = 50^\circ$ :  $M \approx 1,45118 \text{ Nm} \approx 1,5 \text{ Nm}$

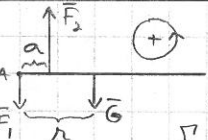
1.13   $m_1 = 15,0 \text{ kg}$ ;  $m = 62 \text{ kg}$ ;  $l = 2,0 \text{ m}$   
 $\Sigma M = G \cdot l + G_1 \cdot \frac{l}{2} = m \cdot g \cdot l + m_1 \cdot g \cdot \frac{l}{2}$   
 $= 2,0 \text{ m} \cdot 9,81 \frac{\text{m}}{\text{s}^2} (62 \text{ kg} + \frac{1}{2} \cdot 15,0 \text{ kg}) = 1363,59 \text{ Nm} \approx 1400 \text{ Nm}$

2.8 a)   $F_2 = 53 \text{ N}$ ;  $r_1 = 0,80 \text{ m}$ ;  $r_2 = 1,20 \text{ m}$   
 Laps on tasapainossa:  
 $\Sigma M_A = F_2 \cdot r_2 - F_1 \cdot r_1 + F_3 \cdot 0 = 0$   
 $\Rightarrow F_1 = \frac{F_2 \cdot r_2}{r_1} = \frac{53 \text{ N} \cdot 1,20 \text{ m}}{0,80 \text{ m}} = 79,5 \text{ N} \approx 80 \text{ N}$

b)   $F_2 = 430 \text{ N}$ ;  $r_1 = 1,20 \text{ m}$ ;  $r_2 = 0,47 \text{ m}$   
 Kallihäiryt ovat tasapainossa:  
 $\Sigma M_A = F_2 \cdot r_2 - F_1 \cdot r_1 + F_3 \cdot 0 = 0$   
 $\Rightarrow F_1 = \frac{F_2 \cdot r_2}{r_1} = \frac{430 \text{ N} \cdot 0,47 \text{ m}}{1,20 \text{ m}} \approx 168,417 \text{ N} \approx 170 \text{ N}$

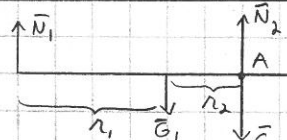
c)   $F_2 = 350 \text{ N}$ ;  $r_1 = 1,80 \text{ m}$ ;  $r_2 = 0,35 \text{ m}$   
 Kambi on tasapainossa:  
 $\Sigma M_A = F_1 \cdot r_1 - F_2 \cdot r_2 + F_3 \cdot 0 = 0$   
 $\Rightarrow F_1 = \frac{F_2 \cdot r_2}{r_1} = \frac{350 \text{ N} \cdot 0,35 \text{ m}}{1,80 \text{ m}} \approx 68,0556 \text{ N} \approx 68 \text{ N}$

d)  $F_1$  on mitä pienempi, mitä pienempi on  $r_2$  ja mitä isompi on  $r_1$ . Siten kambi pitää olla pitkä (iso  $r_1$ ) ja tukitaisi laitetaan lähelle nirelletäessä kiveä (pieni  $r_2$ ).

2.11   $m_1 = 215 \text{ g}$ ;  $m_2 = 420 \text{ g}$   
 $a = 35 \text{ cm}$ ;  $r = 1,4 \text{ m}$   
 Vape on tasapainossa:  
 $\Sigma M_A = F_2 \cdot a - G \cdot r + F_1 \cdot 0 = 0$   
 $\Rightarrow F_2 = \frac{G \cdot r}{a} = \frac{m \cdot g \cdot r}{a}$

1<sup>o</sup>  $F_2 = \frac{m_1 \cdot g \cdot r}{a} = \frac{0,215 \text{ kg} \cdot 9,81 \frac{\text{m}}{\text{s}^2} \cdot 1,4 \text{ m}}{0,35 \text{ m}} = 8,4366 \text{ N}$   
 2<sup>o</sup>  $F_2 = \frac{m_2 \cdot g \cdot r}{a} = \frac{0,42 \text{ kg} \cdot 9,81 \frac{\text{m}}{\text{s}^2} \cdot 1,4 \text{ m}}{0,35 \text{ m}} = 16,4808 \text{ N}$

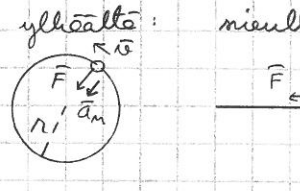
Voimien ero:  $16,4808 \text{ N} - 8,4366 \text{ N} = 8,0442 \text{ N}$   
 Painojen ero:  $G_2 - G_1 = m_2 \cdot g - m_1 \cdot g = 2,01105 \text{ N}$   $\Rightarrow$  väite

2.15   $m_2 = 570 \text{ kg}$ ;  $m_1 = 65 \text{ kg}$   
 $r_1 = 1,4 \text{ m}$ ;  $r_2 = 1,1 \text{ m}$   
 Koska alus on ilman painon (koska alus on ilman painon) tasapainossa, on peräkärryn painopiste renkaiden keskilinjalla.

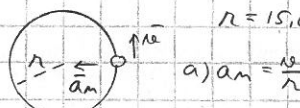
a) Peräkärry on tasapainossa:  
 $\left\{ \begin{aligned} \Sigma \vec{F} = \vec{N}_1 + \vec{N}_2 + \vec{G}_1 + \vec{G}_2 = \vec{0} \quad (1) \\ \Sigma M_A = G_1 \cdot r_1 - N_1 \cdot (r_1 + r_2) = 0 \quad (2) \end{aligned} \right.$   
 (2):  $N_1 = \frac{G_1 \cdot r_1}{r_1 + r_2} = \frac{m_1 \cdot g \cdot r_1}{r_1 + r_2} = \frac{65 \text{ kg} \cdot 9,81 \frac{\text{m}}{\text{s}^2} \cdot 1,1 \text{ m}}{1,4 \text{ m} + 1,1 \text{ m}} = 280,566 \text{ N} \approx 280 \text{ N}$  (ylöspäin)

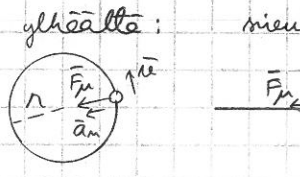
b) (1):  $N_1 + N_2 - G_1 - G_2 = 0$   
 $\Rightarrow N_2 = G_1 + G_2 - N_1 = m_1 \cdot g + m_2 \cdot g - N_1$   
 $= (65 \text{ kg} + 570 \text{ kg}) \cdot 9,81 \frac{\text{m}}{\text{s}^2} - 280,566 \text{ N} = 5948,784 \text{ N} \approx 5,9 \text{ kN}$  (ylöspäin)

c) Peräkärry on ilman painon (koska alus on ilman painon) tasapainossa joten  $N_1 = 0$ . Jos peräkärry asetetaan pyöräin taakse, kerentään aivan reitokoukusta tukivoima  $\vec{N}_1$  alaspäin. Tällöin aine nostaa reitokoukkuun ylöspäin ( $N_{III}$ ) ja paino auton takapyörillä kevenee. Tämä vähentää takapyöräin reitokoukusta.

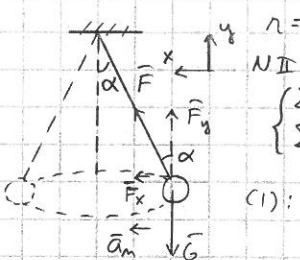
ylhäältä: mieulta  $m = 96 \text{ kg}$   
 $a_m = 998 \frac{\text{m}}{\text{s}^2}$   
  
 NII:  $\Sigma \vec{F} = \vec{F} + \vec{N} + \vec{G} = m \cdot \vec{a}$   
 $\Rightarrow F = m \cdot a_m$

a)  $\vec{F}$ : langan jännitys  
 b)  $F = m \cdot a_m = 0,096 \text{ kg} \cdot 998 \frac{\text{m}}{\text{s}^2} = 95,808 \text{ N} \approx 96 \text{ N}$   
 $\vec{F}$  kohti ympyräradan keskijäistettä

3.8   $r = 15,0 \text{ m}$ ;  $\omega = 5,3 \frac{\text{rad}}{\text{s}}$   
 a)  $a_m = \frac{v^2}{r} = \frac{(5,3 \frac{\text{m}}{\text{s}})^2}{15,0 \text{ m}} \approx 1,87267 \frac{\text{m}}{\text{s}^2} \approx 1,9 \frac{\text{m}}{\text{s}^2}$

3.11 ylhäältä: mieulta  $v = 17 \frac{\text{km}}{\text{h}}$   
 $r = 45 \text{ m}$   
  
 NII:  $\Sigma \vec{F} = \vec{N} + \vec{G} + \vec{F}_m = m \cdot \vec{a}$

Pötkökelkko ei liiku  $\Rightarrow$  kelkko on lepokitossa. Tarvittavaan rajatilanteelle jotta kelkko on täysin kehittyneet lepokitossa:  $F_m = F_{\text{romax}} = \mu_0 \cdot N = \mu_0 \cdot G$   
 Siten  $F_{\text{romax}} = \mu_0 \cdot m \cdot g = m \cdot a_m = m \cdot \frac{v^2}{r}$  | :  $m \cdot g$   
 $\Rightarrow \mu_0 = \frac{v^2}{g \cdot r} = \frac{(17 \frac{\text{m}}{\text{s}})^2}{9,81 \frac{\text{m}}{\text{s}^2} \cdot 45 \text{ m}} \approx 0,050514 \approx 0,051$

3.14   $r = 4,1 \text{ m}$ ;  $\omega = 3,3 \frac{\text{rad}}{\text{s}}$ ;  $m = 22 \text{ kg}$   
 NII:  $\Sigma \vec{F} = \vec{G} + \vec{F} = m \cdot \vec{a}$   
 $\left\{ \begin{aligned} \Sigma F_x = F_x = m \cdot \frac{v^2}{r} \quad (1) \\ \Sigma F_y = F_y - G = F_y - m \cdot g = 0 \quad (2) \end{aligned} \right.$   
 (1):  $F_x = m \cdot \frac{v^2}{r} = 22 \text{ kg} \cdot \frac{(3,3 \frac{\text{m}}{\text{s}})^2}{4,1 \text{ m}} \approx 58,4341 \text{ N}$

(2):  $F_y = m \cdot g = 22 \text{ kg} \cdot 9,81 \frac{\text{m}}{\text{s}^2} = 215,82 \text{ N}$   
 $F = \sqrt{F_x^2 + F_y^2} = \sqrt{(58,4341 \text{ N})^2 + (215,82 \text{ N})^2} \approx 223,531 \text{ N}$

$\tan \alpha = \frac{F_x}{F_y} \Rightarrow \alpha \approx 15,4938^\circ$   
 $\Rightarrow$  köyden jännitys on  $m \cdot 220 \text{ N}$  suunnasta  $15^\circ$  pystysuorasta suunnasta