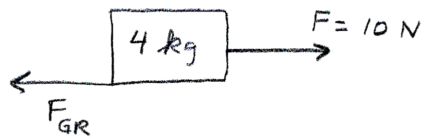
Physik Übung Lösungen
Kraft und Bewegung

Aufgabe 1



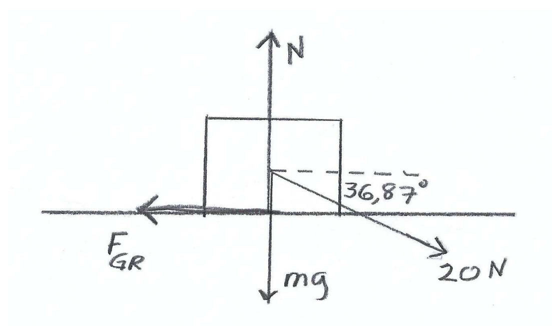
a.

b. The net force, F_{net}, equals mass times acceleration. F_{net} is also equal to $F - F_{GR}$:

$$
\begin{aligned}
F_{net} &= m * a = 4kg * 2\frac{m}{s^2} = 8N \\
F_{net} &= F - F_{GR} \\
F_{gr} &= F - F_{net} = 10N - 8N = 2N
\end{aligned}
$$

c. The coefficient of kinetic friction equals μ_{GR} times the normal force:

$$
\begin{aligned}
F_{GR} &= \mu_{GR} * N = \mu_{GR} mg \\
\mu_{GR} &= \frac{F_{GR}}{m * g} = \frac{2N}{4kg * 9,81\frac{m}{s^2}} \approx 0,051
\end{aligned}
$$



d. For the forces in the vertical direction:

$$F_{net-y} = N - mg - 20 * sin(36,87°) = 0$$
$$N = mg + 20 * sin(36,87°)$$

For the forces in the horizontal direction:

$$\begin{aligned} ma_x &= F_{net-x} \\ &= 20 * cos(36,87°) - \mu_{GR} N \\ ma_x &= 20 * cos(36,87°) - (0,051) * (mg + 36,87 * sin(36,87°)) \\ \rightarrow a_x &= 3,35 \frac{m}{s^2} \end{aligned}$$

Aufgabe 2

a.

b. To find the acceleration of the fish, we use kinematics:

$$\begin{aligned} v^2 &= v_0^2 + 2ax \\ 0 &= 3^2 + 2a * (0,15m) \\ \rightarrow a &= -30 \frac{m}{s^2} \end{aligned}$$

To find the force, we use Newton's second law:

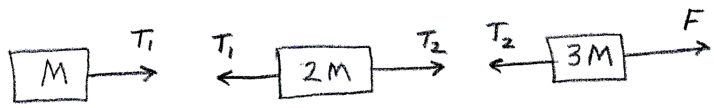
$$|\vec{F}| = m * |a| = 240\,N \quad (1)$$

Aufgabe 3

a.

b. We apply Newton's second law, $F_{net} = ma$ to each block:

$$\begin{aligned} Block\,M &: T_1 = Ma \\ Block\,2M &: T_2 - T_1 = 2Ma \\ Block\,3M &: F - T_2 = 3Ma \end{aligned}$$



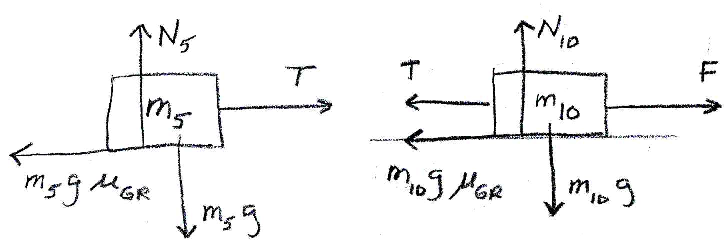
We have three equations with three unknowns, T_1, T_2, and a. To find the acceleration of the system, a, we can simple add the equations and the tensions cancel:

$$\begin{aligned} T_1 + T_2 - T_1 + F - T_2 &= (M + 2M + 3M)a \\ a &= \frac{F}{6M} \end{aligned}$$

c. Now we can solve for T_1 and T_2:

$$\begin{aligned} T_1 &= M * a = M * \frac{F}{6M} = \frac{F}{6} \\ T_2 &= T_1 + 2Ma = \frac{F}{6} + 2M\frac{F}{6M} = \frac{F}{2} \end{aligned}$$

Aufgabe 4



a.

b. We apply Newton's second law to each block:

$$\begin{aligned} 5\,kg\,mass &: T - m_5 g \mu_{GR} = m_5 a \\ 10\,kg\,mass &: F - T - m_{10} g \mu_{GR} = m_{10} a \end{aligned}$$

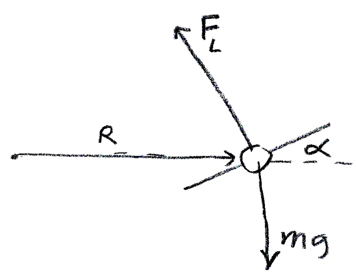
We have two equations with two unknowns, T and a. We can add the equations to find the acceleration:

$$\begin{aligned} F - m_5 g\mu_{GR} - m_{10} g\mu_{GR} &= (m_5 + m_{10})a \\ 80 - (5+10)g\mu_{GR} &= 15a \\ a &= \frac{80N - 15kg * 9,81\frac{m}{s^2} * 0,4}{15kg} \\ &\approx 1,41\frac{m}{s^2} \end{aligned}$$

c. Once we know a, we can solve for T:

$$\begin{aligned} T - m_5 g\mu_{GR} &= m_5 a \\ T &= m_5 a + m_5 g\mu_{GR} \\ T &= = 5kg * 1,41\frac{m}{s^2} + 5kg * 9,81\frac{m}{s^2}0,4 \approx 25,3N \end{aligned}$$

Aufgabe 5



a.

b. Since the plane is flying in a circle with constant speed v, the acceleration equals v^2/R towards the center of the circle. $\vec{F}_{net} = m\vec{a}$.
In the horizontal direction we have

$$\begin{aligned} F_{net} &= ma \\ F_a\, sin(\alpha) &= m\frac{v^2}{R} \end{aligned}$$

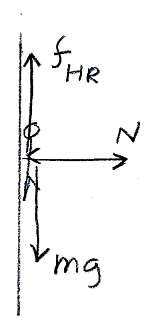
In the vertical direction we have

$$\begin{aligned} F_{net} &= 0 \\ m * g - F_a\, cos(\alpha) &= 0 \\ F_a\, cos(\alpha) &= mg \end{aligned}$$

We can solve for the angle α by dividing the two equations, since F_a and m cancel:

$$\begin{aligned} \frac{sin(\alpha)}{cos(\alpha)} &= \frac{v^2/R}{g} \\ \alpha &= arctan(\frac{v^2}{Rg}) \\ &= arctan(\frac{(\frac{420m}{3,6s})^2}{8000m * 9,81\frac{m}{s^2}}) \approx 9,85^\circ \end{aligned}$$

Aufgabe 6



a. In the vertical direction, the forces add to zero:

$$\begin{aligned} f_{HR} - mg &= 0 \\ f_{HR} &= mg \end{aligned}$$

In the horizontal direction, $F_{net} = ma = mv^2/R$, and $F_{net} = N$:

$$\begin{aligned} N &= F_{net} \\ N &= ma \\ N &= m\frac{v^2}{R} \end{aligned}$$

The maximum value for the frictional force, f_{HR-max} is

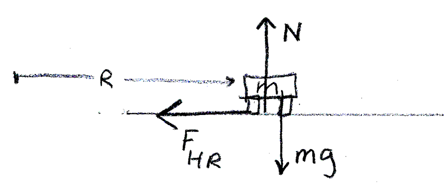
$$\begin{aligned} f_{HR-max} &= \mu_{HR} N \\ f_{HR-max} &= \mu_{HR} m \frac{v^2}{R} \end{aligned}$$

The maximum available frictional force, f_{HR-max}, must be greater than the person's weight if friction is to hold the person up:

$$\begin{aligned} \mu_{HR} m \frac{v^2}{R} &\geq mg \\ v &\geq \sqrt{\frac{gR}{\mu_{HR}}} \end{aligned}$$

$$\begin{aligned} v_{min} &= \sqrt{\frac{gR}{\mu_{HR}}} \\ &= \sqrt{\frac{(9,8)(2,5)}{0,4}} \approx 7,83\, m/s \\ T_{max} &= \frac{2\pi R}{v_{min}} \approx 2,006 s \end{aligned}$$

Aufgabe 7



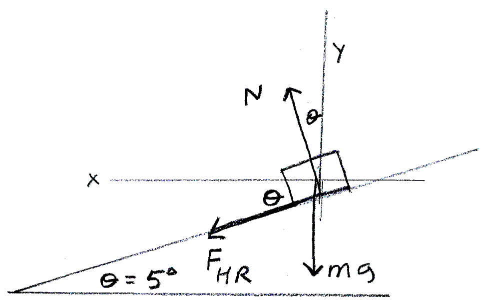
a. The acceleration of the auto equals v^2/R toward the center.

$$\begin{aligned} F_{net} &= ma \\ &= m\frac{v^2}{R} \\ F_{net} &= F_{HR} \\ F_{HR} &= m\frac{v^2}{R} \end{aligned}$$

The maximum value that F_{HR} can have is $\mu_{HR}N$.

$$\begin{aligned}
F_{HR} &\leq \mu_{HR}N = \mu_{HR}mg \\
m\frac{v^2}{R} &\leq \mu_{HR}mg \\
v^2 &\leq \mu g R \\
v_{max} &= \sqrt{\mu_{HR} * g * R} = \sqrt{0,6 * 9,81\frac{m}{s^2} * 5m} \approx 5,42\frac{m}{s} = 19,5\frac{km}{h}
\end{aligned}$$

Aufgabe 8



a.

b. Since the acceleration is in the horizontal direction we use a coordinate system that has horizontal and vertical axes. Since the car moves in uniform circular motion, its acceleration equals v^2/R and is directed toward the center. In the horizontal direction we have

$$\begin{aligned}
F_{net} &= ma \\
f_{HR}\,cos(\theta) + N\,sin(\theta) &= m\frac{v^2}{R}
\end{aligned}$$

In the vertical direction, $F_{net} = 0$, and we have

$$N\,cos(\theta) - mg - f\,sin(\theta) = 0 \qquad (2)$$

The maximum value that f_{HR} can have is

$$f_{max} = \mu_{HR}N \qquad (3)$$

Substituting into the above equations yields:

$$\begin{aligned}\mu_{HR} N\,cos(\theta) + N\,sin(\theta) &= m\frac{v_{max}^2}{R} \\ N\,cos(\theta) - mg - \mu_{HR} N\,sin(\theta) &= 0\end{aligned}$$

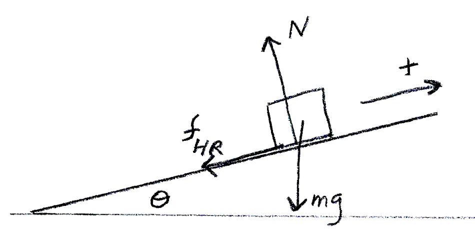
Rearranging the terms gives:

$$\begin{aligned}N(sin(\theta) + \mu\,cos(\theta)) &= m\frac{v_{max}^2}{R} \\ N(cos(\theta) - \mu\,sin(\theta)) &= mg\end{aligned}$$

Dividing the two equations, N and m cancel, and we have

$$\begin{aligned}\frac{sin(\theta) + \mu\,cos(\theta)}{cos(\theta) - \mu\,sin(\theta)} &= \frac{v_{max}^2}{Rg} \\ v_{max} &= \sqrt{Rg(\frac{sin(\theta) + \mu\,cos(\theta)}{cos(\theta) - \mu\,sin(\theta)})} \\ v_{max} &= \sqrt{5m * 9,81\frac{m}{s^2} * \frac{sin5° + cos5° * 0,6}{cos5° - sin5° * 0,6}} \approx 8,432\frac{m}{s} = 30,4\frac{km}{h}\end{aligned}$$

Aufgabe 9



a.

b. For the forces perpendicular to the incline,

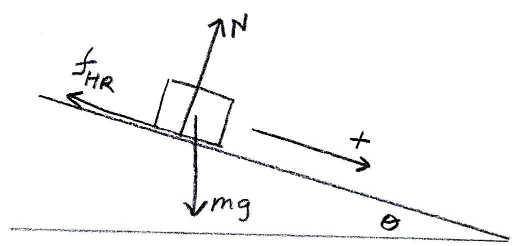
$$\begin{aligned}F_{net} &= 0 \\ N - mg\,cos(\theta) &= 0 \\ N &= mg\,cos(\theta)\end{aligned}$$

For the forces along the incline,

$$\begin{aligned} F_{net} &= ma \\ -f_{HR} - mg\,sin(\theta) &= ma \\ ma &= -f_{HR} - mg\,sin(\theta) \end{aligned}$$

The largest value for f_{HR} is $\mu_{HR}N$, so

$$\begin{aligned} ma_{max} &= -\mu_{HR}N - mg\,sin(\theta) \\ ma_{max} &= -\mu_{HR}mg\,cos(\theta) - mg\,sin(\theta) \\ a_{max} &= -g(\mu_{HR}\,cos(\theta) + sin(\theta)) \end{aligned}$$



c.

d. Traveling down the incline is similar. For the forces perpendicular to the incline we have as before:

$$\begin{aligned} F_{net} &= 0 \\ N - mg\,cos(\theta) &= 0 \\ N &= mg\,cos(\theta) \end{aligned}$$

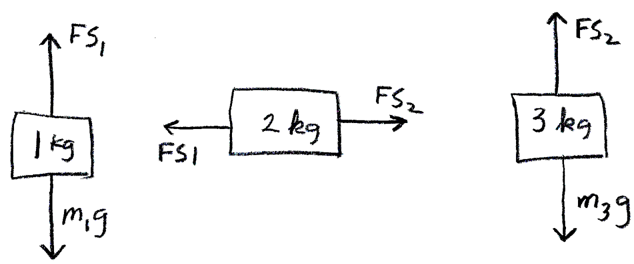
For the forces along the incline, the sign on mg changes:

$$\begin{aligned} F_{net} &= ma \\ -f_{HR} + mg\,sin(\theta) &= ma \\ ma &= -f_{HR} + mg\,sin(\theta) \end{aligned}$$

As before, the largest value for f_{HR} is $\mu_{HR}N$, so

$$\begin{aligned} ma_{max} &= -\mu_{HR}N + mg\,sin(\theta) \\ ma_{max} &= -\mu_{HR}mg\,cos(\theta) + mg\,sin(\theta) \\ a_{max} &= -g(\mu_{HR}\,cos(\theta) + sin(\theta)) \end{aligned}$$

Aufgabe 10



a.

b. We apply Newton's second law to each block:

$$\begin{aligned} 1\,kg\,mass &: FS_1 - m_1g = m_1a \\ 2\,kg\,mass &: FS_2 - FS_1 - m_2g = m_2a \\ 3\,kg\,mass &: m_3g - FS_2 = m_3a \end{aligned}$$

There are three equations with three unknowns, a, FS_1, and FS_2. If we add the three equations, the tensions cancel, and we can solve for the acceleration of the system a:

$$\begin{aligned} m_3g - m_1g &= (m_1 + m_2 + m_3)a \\ a &= \frac{3g - g}{1 + 2 + 3} = \frac{g}{3} \end{aligned}$$

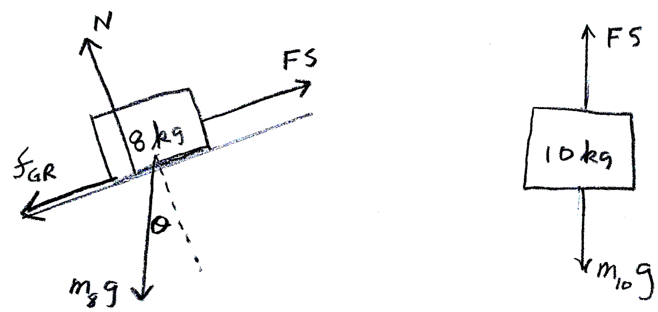
c. We can substitute for a and solve for the tensions FS_1:

$$\begin{aligned} FS_1 - m_1g &= m_1a \\ FS_1 &= m_1(g + a) = \frac{4}{3}m_1g \approx 13,1\,N \end{aligned}$$

and FS_2:

$$\begin{aligned} m_3 g - FS_2 &= m_3 a \\ FS_2 &= m_3(g-a) = \frac{2}{3} m_3 g \approx 19,6\,N \end{aligned}$$

Aufgabe 11



a.

b. For the block on the incline: the forces parallel to the incline:

$$\begin{aligned} F_{net} &= m_8 a \\ FS - f_{GR} - m_8 g\, sin(\theta) &= m_8 a \end{aligned}$$

for the forces perpendicular to the incline:

$$\begin{aligned} F_{net} &= 0 \\ N - m_8 g\, cos(\theta) &= 0 \\ N &= m_8 g\, cos(\theta) \end{aligned}$$

The sliding frictional force f_{GR} is

$$\begin{aligned} f_{GR} &= \mu_{GR} N \\ f_{GR} &= \mu_{GR} m_8 g\, cos(\theta) \end{aligned}$$

Substuting into the equation above, we have

$$FS - m_8 g \mu_{GR} cos(\theta) - m_8 g\, sin(\theta) = m_8 a \qquad (4)$$

For the hanging block, Newton's second law gives:

$$\begin{aligned} F_{net} &= m_{10}a \\ m_{10}g - FS &= m_{10}a \end{aligned}$$

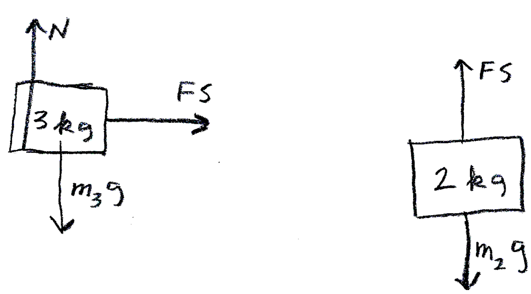
We have two equations with two unknowns, a and FS. Adding two of the force equations, FS will cancel:

$$\begin{aligned} m_{10}g - m_8 g \mu_{GR} cos(\theta) - m_8 g\, sin(\theta) &= (m_{10} + m_8)a \\ a &= \frac{m_{10}g - m_8 g \mu_{GR} cos(\theta) - m_8 g\, sin(\theta)}{m_8 + m_{10}} \\ a &\approx 0,256g \approx 2,51\, m/s^2 \end{aligned}$$

c. We can substitute for a to find FS:

$$\begin{aligned} m_{10}g - FS &= m_{10}a \\ FS &= m_{10}(g - a) \approx 72,9\, N \end{aligned}$$

Aufgabe 12



a.

b. Applying Newton's second law to the block on the table:

$$\begin{aligned} F_{net} &= m_3 a \\ FS &= m_3 a \end{aligned}$$

Applying Newton's second law to the hanging block:

$$m_2 g - FS = m_2 a \tag{5}$$

We have two equations with two unknowns, a and FS. We can solve for the acceleration a by adding the equations. The tension FS cancels:

$$\begin{aligned} m_2 g &= (m_3 + m_2)a \\ a &= \frac{m_2 * g}{m_1 + m_2} \\ &= \frac{2}{5}g \approx 3,92\frac{m}{s^2} \end{aligned}$$

Since we know the acceleration, which is constant, and the distance, we can solve for the speed of the block:

$$\begin{aligned} v^2 &= v_0^2 + 2ax \\ v^2 &= 0 + 2ax \\ v &= \sqrt{2 * a * x} \\ v &\approx \sqrt{2(3,93)(1,5)} \approx 3,43\frac{m}{s} \end{aligned}$$

c. With friction, the equations are the same except for the addition of the frictional force on the $3\,kg$ block. The frictional force f_{GR} equals $\mu_{GR}N = \mu_{GR}m_3g$:

$$\begin{aligned} 3\,kg\,mass &: FS - m_3 g \mu_{GR} = m_3 a \\ 2\,kg\,mass &: m_2 g - FS = m_2 a \end{aligned}$$

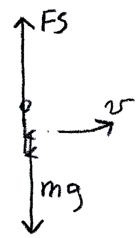
As before, we can add the equations to find a:

$$\begin{aligned} m_2 g - m_3 g \mu_{GR} &= (m_3 + m_2)a \\ a &= \frac{m_2 * g - m_3 * g * \mu}{m_3 + m_2} \approx 3,04\frac{m}{s^2} \end{aligned}$$

With this new value for the acceleration, we can calculate the speed v:

$$\begin{aligned} v^2 &= v_0^2 + 2ax \\ v^2 &= 0 + 2ax \\ v &= \sqrt{2 * a * x} \\ &\approx \sqrt{2(3.04)(1,5)} \approx 3,02\frac{m}{s} \end{aligned}$$

Aufgabe 13



a.

b. At the bottom of the swing, we apply Newton's second law:

$$\begin{aligned} F_{net} &= ma \\ FS - mg &= ma \\ FS - mg &= m\frac{v^2}{R} \\ FS &= mg + m\frac{v^2}{R} \end{aligned}$$

The acceleration of the father at the bottom of the swing is v^2/R. Since $FS_{max} = 2000\,N$, we have for v_{max}:

$$\begin{aligned} 2000\,N &= mg + m\frac{v_{max}^2}{R} \\ 2000\,N &= 150(9,8) + 150\frac{v_{max}^2}{4} \\ v_{max} &\approx 3,75\,m/s \end{aligned}$$

Aufgabe 14

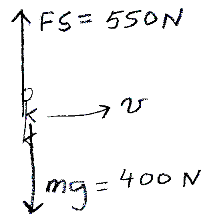
a.

b. The mass of the boy is:

$$m = \frac{400N}{9,81\frac{m}{s^2}} \approx 40,8\,kg \qquad (6)$$

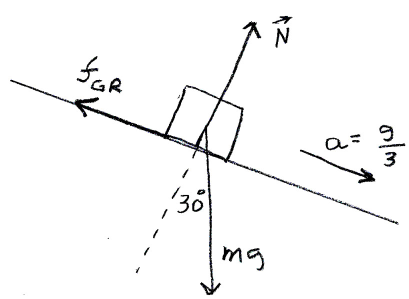
Applying Newton's second law at the bottom of the swing:

$$F_{net} = ma$$



$$
\begin{aligned}
FS - mg &= ma \\
&= m\frac{v^2}{R} \\
550\,N - 400\,N &= 40,8 * \frac{v^2}{3,5\,m} \\
v &= \sqrt{\frac{150N * 3,5m}{40,8kg}} \approx 3,59\frac{m}{s}
\end{aligned}
$$

Aufgabe 15



a.

b. Applying Newton's second law in a direction perpendicular to the incline:

$$
\begin{aligned}
F_{net} &= 0 \\
N - mg\,cos(\alpha) &= 0 \\
N &= mg\,cos(\alpha)
\end{aligned}
$$

Applying Newton's law along the incline:

$$\begin{aligned} F_{net} &= ma \\ m * g * sin(\alpha) - f_{GR} &= ma \end{aligned}$$

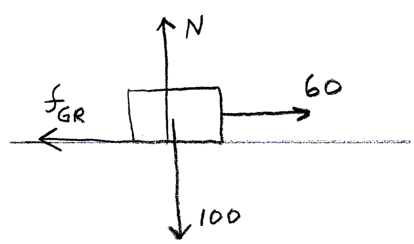
The kinetic friction f_{GR} equals $\mu_{GR}N$:

$$f_{GR} = \mu_{GR}N = \mu_{GR}mg\,cos(\alpha) \tag{7}$$

Substituting into the equation above we have

$$\begin{aligned} m * g * sin(\alpha) - \mu_{GR}m * g * cos(\alpha) &= ma \\ m * g * sin(30°) - \mu_{GR}m * g * cos(30°) &= m\frac{g}{3} \\ \mu &= \frac{sin(30°) - \frac{1}{3}}{cos(30°)} \\ &= \frac{\frac{1}{2} - \frac{1}{3}}{\frac{\sqrt{3}}{2}} \\ \mu &= \frac{1}{3\sqrt{3}} \end{aligned}$$

Aufgabe 16

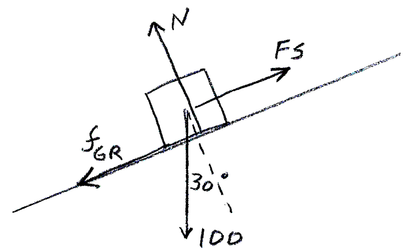


a.

b. Applying Newton's second law when the block is pulled on the level surface:

$$\begin{aligned} 60\,N - f_{GR} &= 0 \\ f_{GR} &= 60\,N \end{aligned}$$

$$
\begin{aligned}
\mu_{GR} N &= 60\,N \\
\mu_{GR} mg &= 60\,N \\
\mu_{GR}(100) &= 60\,N \\
\mu_{GR} &= 0,6
\end{aligned}
$$



c.

d. Since the weight of the block is 100 units, the normal force that the incline exerts on the block is $N = 100\,cos(30°)$. Applying Newton's second law when the block is pulled up the incline gives:

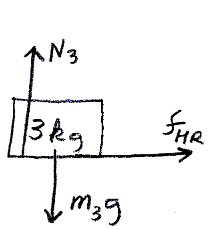
$$
\begin{aligned}
F_{net} &= 0 \\
FS - 100\,sin(30°) - f_{GR} &= 0 \\
FS &= 100\,sin(30°) + \mu_{GR} N \\
&= 100\,sin(30°) + \mu_{GR}(100)\,cos(30°) \\
&= 100\,sin(30°) + 0,6(100)\,cos(30°) \\
&= 50 + 30\sqrt{3} \\
FS &\approx 102N
\end{aligned}
$$

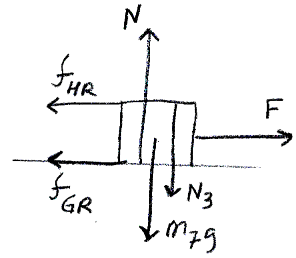
Aufgabe 17

a.

b. Consider first the $3\,kg$ block. In the vertical direction, the normal force exerted on the block is $N_3 = m_3 g$. We can apply Newton's second law in the horizontal direction:

$$
\begin{aligned}
F_{net} &= m_3 a \\
f_{HR} &= m_3 a
\end{aligned}
$$





The maximum value that the static friction f_{HR} can have equals $\mu_{HR} N_3$.

$$\begin{aligned}
f_{HR-max} &= m_3 a_{max} \\
\mu_{HR} N_3 &= m_3 a_{max} \\
\mu_{HR} m_3 g &= m_3 a_{max} \\
a_{max} &= \mu_{HR} g \\
a_{max} &= \frac{g}{4} \approx 2,45 \frac{m}{s^2}
\end{aligned}$$

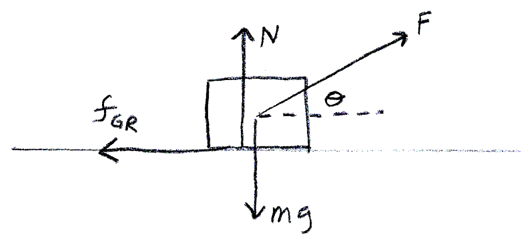
c. Now consider the forces on the $7\,kg$ block. In the vertical direction we have

$$\begin{aligned}
N - N_3 - m_7 g &= 0 \\
N &= N_3 + m_7 g \\
N &= (m_3 + m_7) g
\end{aligned}$$

In the horizontal direction, when $a = a_{max}$, we have:

$$\begin{aligned}
F_{net} &= m a_{max} \\
F_{max} - f_{HR-max} - f_{GR} &= m_7 a_{max} \\
F_{max} - m_3 a_{max} - \mu_{GR} N &= m_7 a_{max} \\
F_{max} &= (m_3 + m_7) a_{max} + \mu_{GR} N \\
&= (m_3 + m_7) a_{max} + \mu_{GR} (m_3 + m_7) g \\
&= (10\,kg) \frac{g}{4} + (0,2)(10\,kg) g = (4,5\,kg) g \\
F_{max} &\approx 44,1\,N
\end{aligned}$$

Aufgabe 18



a.

b. Applying Newton's second law in the vertical direction:

$$\begin{aligned} N + Fsin(\theta) - mg &= 0 \\ N &= mg - Fsin(\theta) \end{aligned}$$

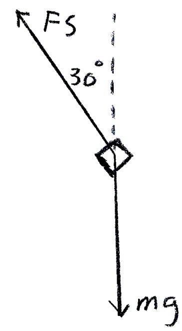
Applying Newton's second law in the horizontal direction,

$$\begin{aligned} Fcos(\theta) - f_{GR} &= ma \\ Fcos(\theta) - f_{GR} &= 0 \end{aligned}$$

since the acceleration is zero. The kinetic friction f_{GR} equals $\mu_{GR}N$, which gives:

$$\begin{aligned} Fcos(\theta) &= f_{GR} \\ &= \mu_{GR}N \\ Fcos(\theta) &= \mu_{GR}(mg - Fsin(\theta)) \\ F &= \frac{\mu_{GR}\, mg}{cos(\theta) + \mu_{GR}\, sin(\theta)} \end{aligned}$$

Aufgabe 19



a.

b. Applying Newton's second law in the vertical direction:

$$\begin{aligned} F_{net} &= 0 \\ FS\,cos(30°) - mg &= 0 \\ FS\,cos(30°) &= mg \end{aligned}$$

Applying Newton's second law in the horizontal direction, where the acceleration $a = v^2/R$:

$$\begin{aligned} F_{net} &= ma \\ FS\,sin(30°) &= m\frac{v^2}{R} \end{aligned}$$

If we divide the two equations, then the tension FS and m cancel:

$$tan(30°) = \frac{v^2}{Rg} \quad (8)$$

Solving for v we have

$$\begin{aligned} R &= (8m)\,sin(30°) = 4\,m \\ v &= \sqrt{Rg\,tan(30°)} \approx 4,760\frac{m}{s} \end{aligned}$$

c. Solving for the tension FS:

$$\begin{aligned} FS\,cos(30°) &= mg \\ FS &= \frac{mg}{cos(30°)} \\ &= \frac{120(9,8)}{cos(30°)} \approx 1359\,N \end{aligned}$$

d. The apparent weight is the same force as the tension if the mass were $50\,kg$:

$$Apparent\,Weight = \frac{(50\,kg)\,g}{cos(30°)} \approx (57,7\,kg)\,g \tag{9}$$

Aufgabe 20

a. Since the velocity is constant, the net horizontal forces add to zero:

$$\begin{aligned} F_0 - F_r - F_{lw} &= 0 \\ F_0 &= F_r + F_{lw} \end{aligned}$$

The rolling friction force F_r is constant:

$$F_r = c_r mg = (0,01)(1500)(9,8) \approx 147\,N \tag{10}$$

The air friction force depends on the speed v:

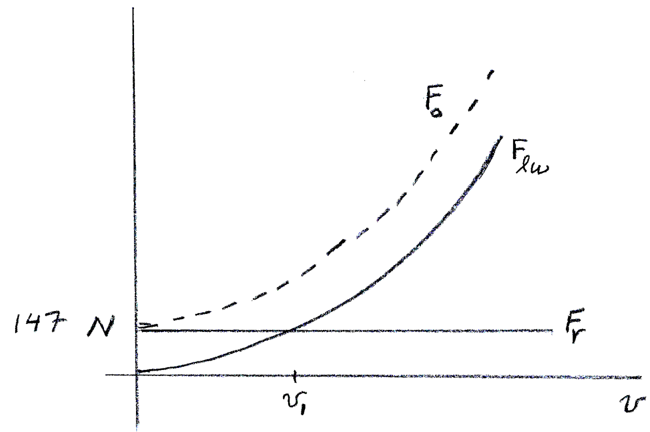
$$\begin{aligned} F_{lw} &= \frac{1}{2}c_w * A * \rho * v^2 \\ &= \frac{1}{2}(0,32)(2,4)(1,2)v^2 \\ &\approx 0,4608\,v^2 \end{aligned}$$

where v is in units of m/s. The force F_0 is therefore:

$$F_0 = 147\,N + 0,4608(\frac{100}{3,6})^2 \approx 502,6\,N \tag{11}$$

The power is the force times speed:

$$\begin{aligned} P_0 &= F_0 * v_0 \\ &= (502\,N)(\frac{100}{3,6} \approx 13,96\,kW \end{aligned}$$



b.

c. To find the speed where air friction equals rolling friction:

$$\begin{aligned} F_{lw} &= F_r \\ 0,4608\, v_1^2 &= 147 \\ v_1 &= \sqrt{\frac{147}{0.4608}} \\ &\approx 17,86\,\frac{m}{s} \approx 64,3\,\frac{km}{h} \end{aligned}$$

d. For a force F_0 of $1500\,N$, the speed v that can be reached is found by solving the following equation:

$$\begin{aligned} 1500 &= 147 + 0,4608\, v^2 \\ v &= \sqrt{(1500 - 147)/0,4608} \\ &\approx 51,8\frac{m}{s} \approx 186,5\frac{km}{h} \end{aligned}$$

The power at this speed is

$$P = F * v = 1500(51,8) \approx 77,7\,kW \tag{12}$$

e. When the brakes are applied, the equation of motion becomes:

$$m\ddot{x} = -\frac{1}{2}c_w \rho A \dot{x}^2 - \mu\, mg \tag{13}$$

f. If air friction is neglected, then the first term on the right side is zero. If the brakes lock, then there is sliding friction, $\mu_{GR} N$, instead of rolling friction. The equation of motion becomes:

$$\begin{aligned} m\ddot{x} &= -\mu_{GR}\, mg \\ a &= -0,5g \end{aligned}$$

Using the equations for constant acceleration, we can solve for x:

$$\begin{aligned} v^2 &= v_0^2 + 2ax \\ 0 &= v_0^2 - 2(0,5g)x \\ x &= \frac{v_0^2}{2(0,5)g} \\ x &= \frac{\left(\frac{100m}{3{,}6s}\right)^2}{2 * 0,5 * 9,81\frac{m}{s^2}} \approx 78,7\, m \end{aligned}$$