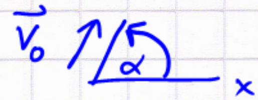
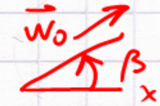
Week 4 4.35





A golf ball is hit : $\vec{v}_0$: $v_0 = 60\ \frac{m}{s}$, $\alpha = 65°$

same time : 2^{nd} ball $w_0 = ?$, $\beta = 35°$

Both balls land at the same time. What is w_0?

Solution. Landing time has something to do with the vertical motion $(y(t_f) = y_0 = 0)$

For either ball : $y_1(t) = (v_0 \sin\alpha)t - \frac{1}{2} g t^2$

$y_2(t) = (w_0 \sin\beta)\, t - \frac{1}{2} g t^2$

solve $y_1(t_f) = 0 \quad \therefore \quad 0 = t_f \left[v_0 \sin\alpha - \frac{1}{2} g t_f \right]$

We know $t_f \neq 0$ (corresponds to $y(0) = 0$) $\therefore [\ldots] = 0$

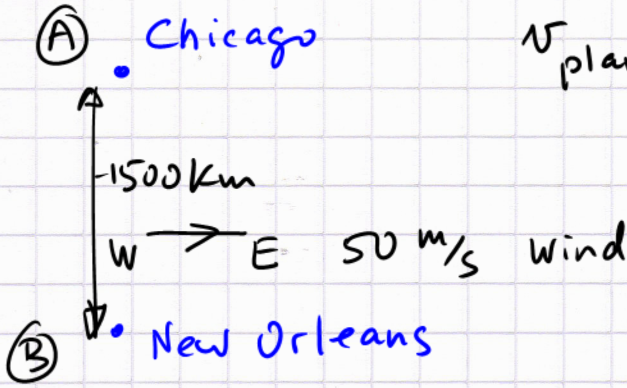
$\therefore \quad t_f = \dfrac{v_0 \sin\alpha}{\frac{1}{2} g}$ and : $t_f = \dfrac{w_0 \sin\beta}{\frac{1}{2} g}$

$\therefore \quad v_0 \sin\alpha = w_0 \sin\beta$

$w_0 = v_0 \dfrac{\sin\alpha}{\sin\beta} \quad \therefore \quad w_0 = 60 \dfrac{\sin(65°)}{\sin(35°)}\ \frac{m}{s}$

$= 94.8\ \frac{m}{s} = 95\ \frac{m}{s}$

4.41



$v_{plane} = 250\ \mathrm{m/s}$ w.r.t. air

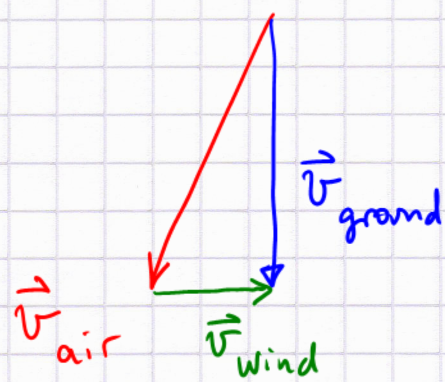
$v_{ground,\,A\to B} = ?$

$v_{ground,\,B\to A} = ?$

average speed ?

Solution. 250 m/s and 50 m/s are on a similar scale

To fly geographically N → S the pilot has to aim the plane in the westward direction



$v_{air} = 250\ \mathrm{m/s}$

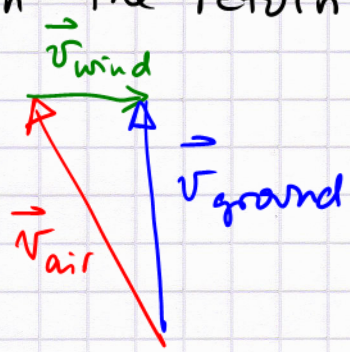
$v_{wind} = 50\ \mathrm{m/s}$

$$v_{ground}^2 = v_{air}^2 - v_{wind}^2$$

$v_{ground,\,A\to B} = 245\ \frac{m}{s}$

(textbook rounded down to $240\ \frac{m}{s}$)

On the return:



Same calculation, $v_{ground,\,B\to A} = 245\frac{m}{s}$

The average speed for the return trip:

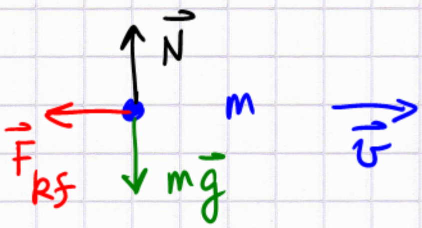
$$v_{avg} = 245\ \frac{m}{s}$$

4.45 Car on level ground, $v = 25\ \mathrm{m/s}$, breaking distance $= 22\,\mathrm{m}$ (sliding friction) = kinetic

Now on 8.0° incline:

what is the stopping distance (along the incline)?

Solution. Skidding, locked wheels = kinetic friction



$F_{kf} = \mu_k N$

constant acceleration

$\rightarrow\ v_f^2 = v_0^2 + 2a\,\Delta x$

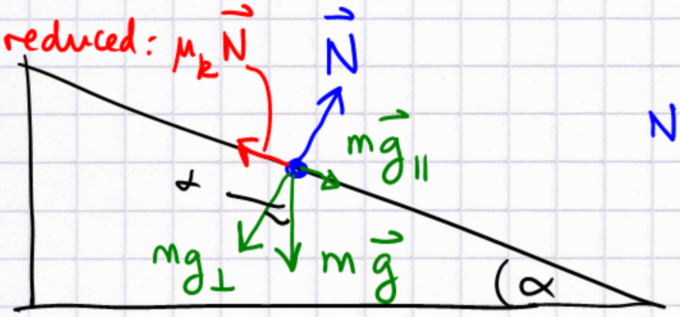
$0 = v_0^2 + 2a\,\Delta x$

$\Delta x = \dfrac{-v_0^2}{2a} \quad (a<0)$

$|a| = \dfrac{v_0^2}{2\,\Delta x} \quad \therefore \quad |a| = 12.5\ \mathrm{m/s}$

Now apply this on the incline, where gravity accelerates forward?

No, we can't just use the same a break, since we are skidding! μ_k the same, but not N!



$N = mg\cos\alpha \qquad g_{\parallel} = g\sin\alpha$

$\Delta x_I = \dfrac{-v_0^2}{2a_I}; \quad a_I = g\sin\alpha - \mu_k g\cos\alpha$

$\mu_k = ?$

From level: $m|a| = \mu_k mg$

$\mu_k = \dfrac{v_0^2}{2g\,\Delta x}$

$\therefore\ \Delta x_I = \dfrac{-v_0^2}{2g\sin\alpha - (v_0^2/\Delta x)\cos\alpha}$

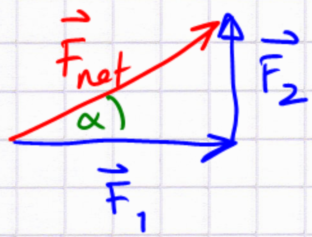
$\Delta x_I = 24.6\ \mathrm{m} = 25\ \mathrm{m}.$

4.51 $F_1 = 45\,N$ $\quad \vec{F}_1 = F_1\,\hat{\imath}$

$F_2 = 30\,N$ $\quad \vec{F}_2 = F_2\,\hat{\jmath}$

direction of acceleration?

Solution.



$$\tan\alpha = \frac{F_2}{F_1}$$

$$\alpha = \tan^{-1}\left(\frac{F_2}{F_1}\right)$$

$$\alpha = \tan^{-1}\left(\frac{2}{3}\right) = 0.588 \text{ rad}$$

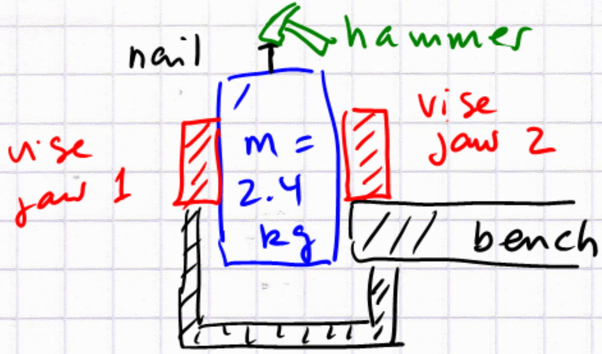
$$\alpha = 33.7^\circ = 34^\circ$$

Note: in general: $F_{net,y} = \sum_i F_{i,y}$

$F_{net,x} = \sum_i F_{i,x}$!

$$\tan\alpha = \frac{F_{net,y}}{F_{net,x}}$$

4.68



$F_{nail} = 450\ N$

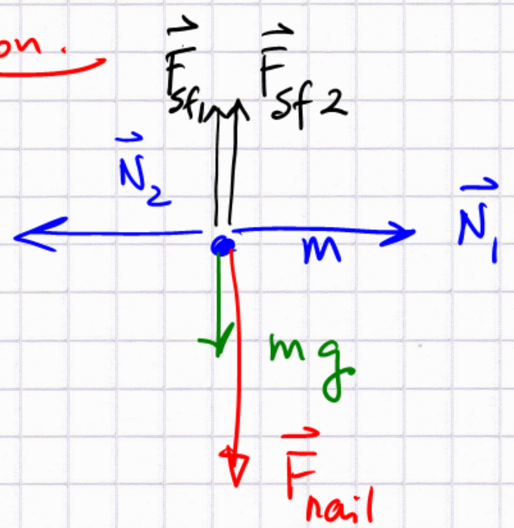
$\vec{F}_{nail} = -F_{nail}\,\hat{j}$

$\mu_s = 0.67$

minimum normal force from each jaw?

Solution.

FB diagram



When we ask about the minimum normal force required, we are working at the limit: $F_{sf} \lessapprox \mu_s N$

$\approx$ applies

Note: while the forces $\vec{N}_1 + \vec{N}_2$ cancel, i.e., there is no horizontal acceleration, each of them <u>does</u> provide friction!

y-direction: (magnitudes!)

$$F_{sf_1} + F_{sf_2} = mg + F_{nail}$$

$$2\mu_s N_1 = mg + F_{nail} \qquad (N_2 = N_1)$$

$$N_1 = \frac{mg + F_{nail}}{2\mu_s} \quad \therefore \quad N_1 = \frac{23.5 + 450}{2 \cdot 0.67} = 353\ N = \underline{350\ N}$$