PHY1124 Assignment 4 solutions 2018

1. Forces on driver are $\vec{F}_N$ (vertically) by seat, $\vec{F}_h$ horizontally by seat, and $\vec{F}_g$ by earth.

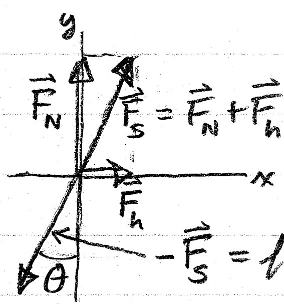
– on horizontal road, $0 = ma_y = (\vec{F}_N + \vec{F}_g + \vec{F}_h)_y = F_N - mg$

$\therefore \vec{F}_N = mg\hat{j}$ and $F_N = mg = (75\,kg)(9.8\,m/s^2) = 735\,N$

$ma_x = (\vec{F}_N + \vec{F}_g + \vec{F}_h)_x = F_{h,x}$ so for circular turn,

$$F_{h,x} = ma_x = m\frac{v^2}{r} = (75\,kg)\frac{(25\,m/s)^2}{400\,m} \leftarrow 90\frac{km}{h} \times \frac{1000\,m/km}{3600\,s/h} = 25\,m/s$$

$$= 117\,N$$

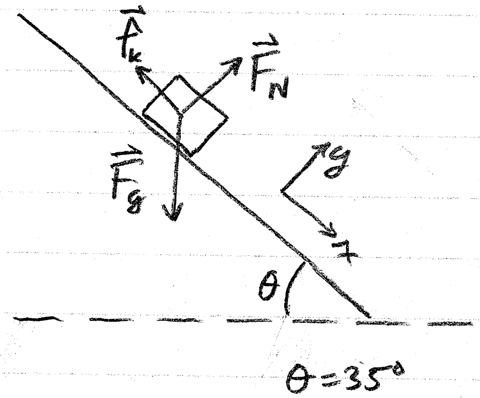


$\therefore$ Magnitude of force by driver on seat is

$$|-\vec{F}_s| = (F_N^2 + F_h^2)^{1/2} = (735^2 + 117^2)^{1/2} = 744\,N$$

and direction θ as shown is

$$\tan\theta = \frac{F_h}{F_N} = \frac{117\,N}{735\,N} = 0.159 \Rightarrow \theta = \tan^{-1}(0.159) = 9.0°$$



2. $0 = ma_y = F_y = F_N - mg\cos\theta$

$\Rightarrow F_N = mg\cos\theta$

$ma_x = F_x = mg\sin\theta - \mu_k F_N$

$= mg\sin\theta - \mu_k mg\cos\theta$

$\therefore a_x = g(\sin\theta - \mu_k\cos\theta)$

$\therefore$ time taken to slide from rest to a distance x down along plane is given by $x = \frac{1}{2}a_x t^2$

$\therefore t = \sqrt{\frac{2x}{a_x}} = \left(\frac{2x}{g(\sin\theta - \mu_k\cos\theta)}\right)^{1/2}$

$\therefore$ If no friction (setting $f_k = 0$, i.e. $\mu_k = 0$)

$\Rightarrow t_{\substack{no\\friction}} = \left(\frac{2x}{g\sin\theta}\right)^{1/2}$

$\therefore \frac{t}{t_{\substack{no\\friction}}} = \left(\frac{2x}{g(\sin\theta - \mu_k\cos\theta)}\right)^{1/2}\left(\frac{2x}{g\sin\theta}\right)^{-1/2}$

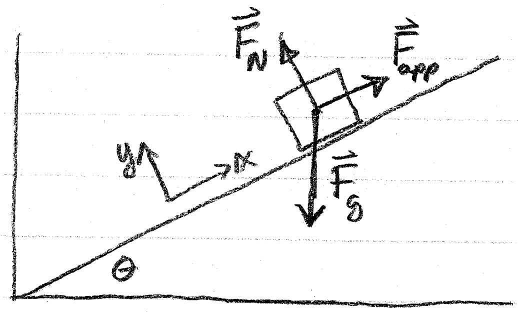
$= \left(\frac{\sin\theta}{\sin\theta - \mu_k\cos\theta}\right)^{1/2}$

$= \left(\frac{\sin 35°}{\sin 35° - 0.2\cos 35°}\right)^{1/2}$

$= \left(\frac{0.574}{0.574 - 0.2(0.819)}\right)^{1/2}$

$\therefore \frac{t}{t_{\substack{no\\friction}}} = 1.18$

3. a)



$\sin\theta = \frac{1.2\,m}{2.8\,m} = 0.429 \Rightarrow \theta = 25.4°$

Force applied by person to block is $\vec{F}_{app}$.

$W_{\substack{by\\person}} = \vec{F}_{app} \cdot \Delta\vec{r} = F_{app,x}\Delta x$

Find $F_{app,x}$:

Since $\vec{v}$ = const. $\therefore \vec{a} = 0$

$\therefore 0 = ma_x = F_x = F_{g,x} + F_{app,x}$

$\therefore F_{app,x} = -F_{g,x} = -(-mg\sin\theta) = mg\sin\theta$
$= (20\,kg)(9.8\,\frac{m}{s^2})(0.429) = 84.1\,N$

$\therefore W_{\substack{by\\person}} = F_{app,x}\Delta x = (84.1\,N)(-2.8\,m) = -235\,J$

b) $W_{\substack{by\\gravity}} = \vec{F}_g \cdot \Delta\vec{r} = F_{g,x}\Delta x = (-mg\sin\theta)\Delta x$

$= -(20\,kg)(9.8\,\frac{m}{s^2})(0.429)(-2.8\,m) = 235\,J$

c) Since $\vec{v}$ = constant, $\therefore \vec{a} = 0$, $\therefore \vec{F}_{net} = m\vec{a} = 0$,

$\therefore W_{total} = \vec{F}_{net} \cdot \Delta\vec{r} = 0$

d) Since $\vec{F}_N \perp$ plane, $\therefore \vec{F}_N \perp \Delta\vec{r}$

$\therefore W_{by\,\vec{F}_N} = \vec{F}_N \cdot \Delta\vec{r} = 0$