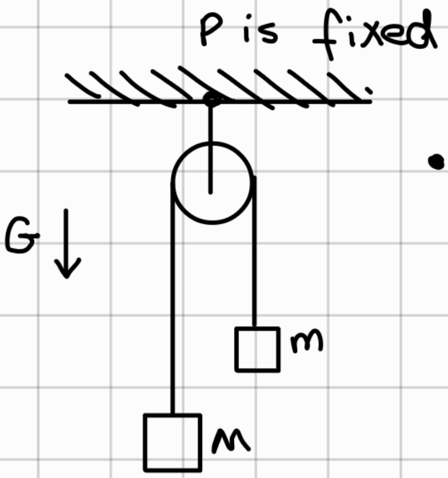
PHYS 301 Lecture 6

09.10.24

Procedure for Solvin g Problems

Write clearly and clearly

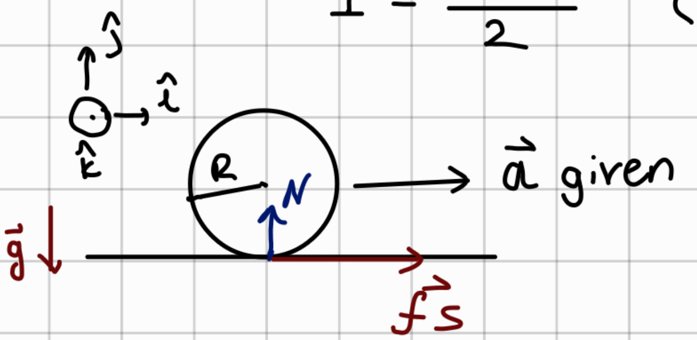
1) Fix a coordinate system with unit vectors
2) Identify the knowns and unknowns
3) Write down all equations (include all constraint equations)
4) Solve them
5) Interpret the meaning of the result.



- length of the rope is constant

$$I = \frac{mR^2}{2}$$

(rolls without slipping)



$N + mg = 0$

$f_s = ma$

$V = \omega R$

$a = \alpha R$

$$\vec{\tau} = \underbrace{\vec{\tau}_{f_s}} + \underbrace{\vec{\tau}_{engine}}$$

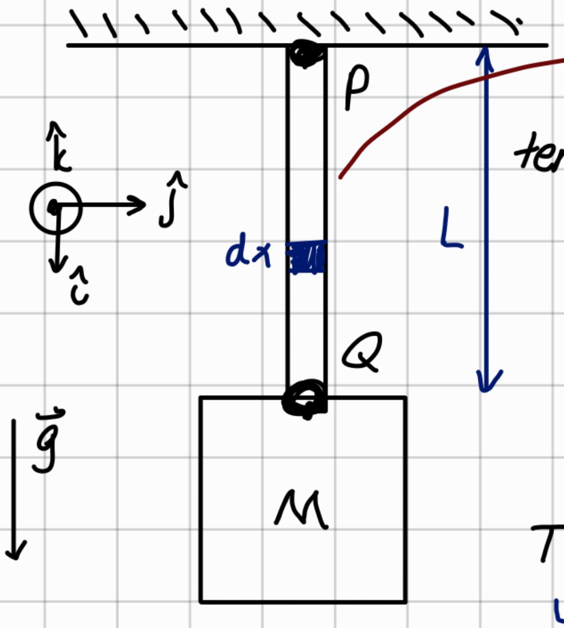
$$+Rma\hat{k} + \vec{\tau}_{engine} = -I\alpha\hat{k} = -\frac{mR^{\cancel{2}}}{2}\frac{a}{\cancel{R}} = -\frac{mRa}{2}$$

$$\vec{\tau}_{engine} = -\frac{3}{2}mRa\hat{k}$$

This can't be true for all a's

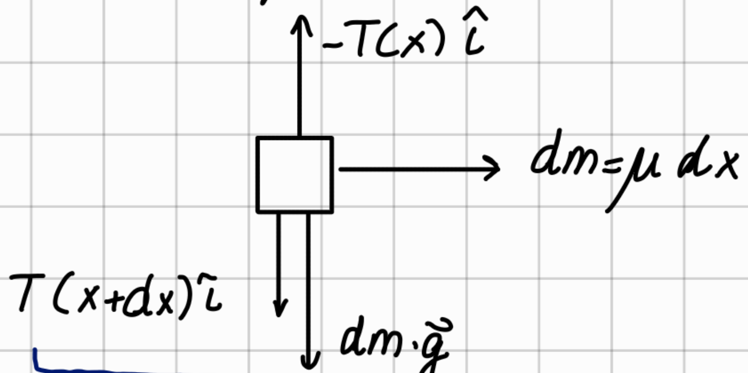
- $\vec{f}_s^{\,(max)} = \mu_s N = \mu_s mg \quad \Rightarrow \quad \vec{a}^{\,(max)} = \mu_s g$

$$\left|\vec{\tau}^{\,(max)}_{engine}\right| = \frac{3}{2} mR\mu_s g$$



Rope is massive, homogeneous $\mu = \frac{m}{L}$

tension depends on position on the rope



$$\vec{F} = \vec{a}\, dm = 0 = \hat{i}\left(T(x+dx) - T(x) + \mu g\, dx\right) = 0$$

$$\underbrace{T(x+dx) - T(x)}_{T(x) + dx\,\frac{dT}{dx} + \cdots} = -\mu g\, dx$$

Taylor expansion:

$$\frac{dT}{dx} = -\mu g$$

$$\boxed{T(x) = -\mu g x + const}$$

P carries the full weight $T_P = T(x=0) = (M+m)g$

Car and Air Friction

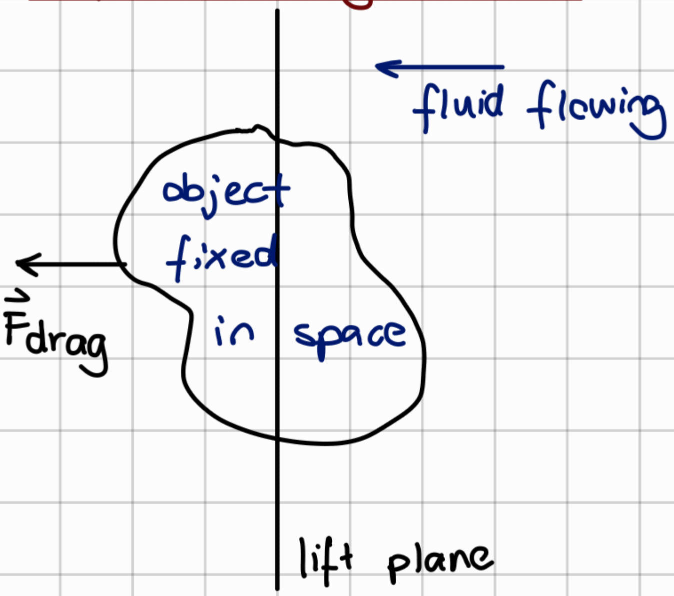
$$\vec{F}_{Turbulent} = -\frac{1}{2} c_D \rho_{air} \overbrace{S}^{\text{projected area}} v^2 \hat{v}$$

any $\vec{F}$ due to engine can deal with this.

$$|\vec{F}_{engine}| = \frac{1}{2} c_D \rho_{air} S \, v^2_{limit}$$

* Remember direction of acceleration has less acceleration

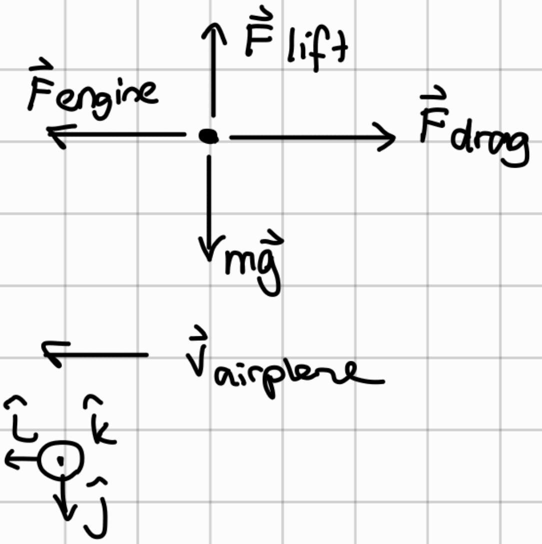
Lift and Drag Forces



$$|\vec{F}_{drag}| = \frac{1}{2} c_D \rho S v^2$$

$$|\vec{F}_{lift}| = \frac{1}{2} c_L \rho S v^2$$

Air Planes



$$mg = \frac{1}{2} c_L \rho S v^2 \qquad v^2 = \frac{2mg}{C_L \rho S}$$

$$F_e = \frac{1}{2} c_D \rho S v^2$$

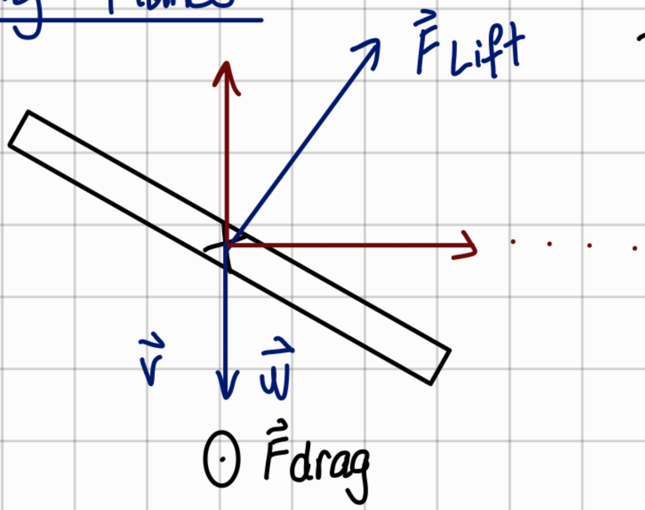
$$F_e = \frac{1}{\cancel{2}} c_D \cancel{\rho S} \frac{\cancel{2} mg}{C_L \cancel{\rho S}}$$

$$\boxed{F_e = \frac{C_D}{C_L} mg}$$

$$P_{engine} = F_e \cdot v = \frac{C_D}{C_L}\sqrt{\frac{2}{C_L \rho S}}\,(mg)^{3/2}$$

- Denser air is better for the power.
- When there's considerable humidity, ρ will ↓

Banking Planes



They increase the power a bit to not lose altitude (have to go faster)