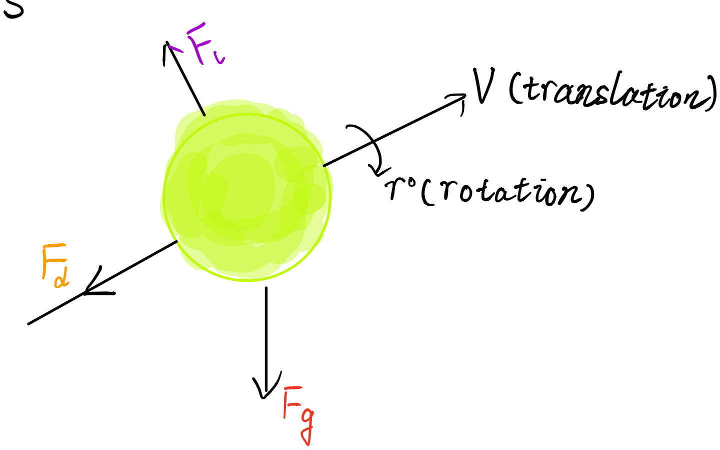
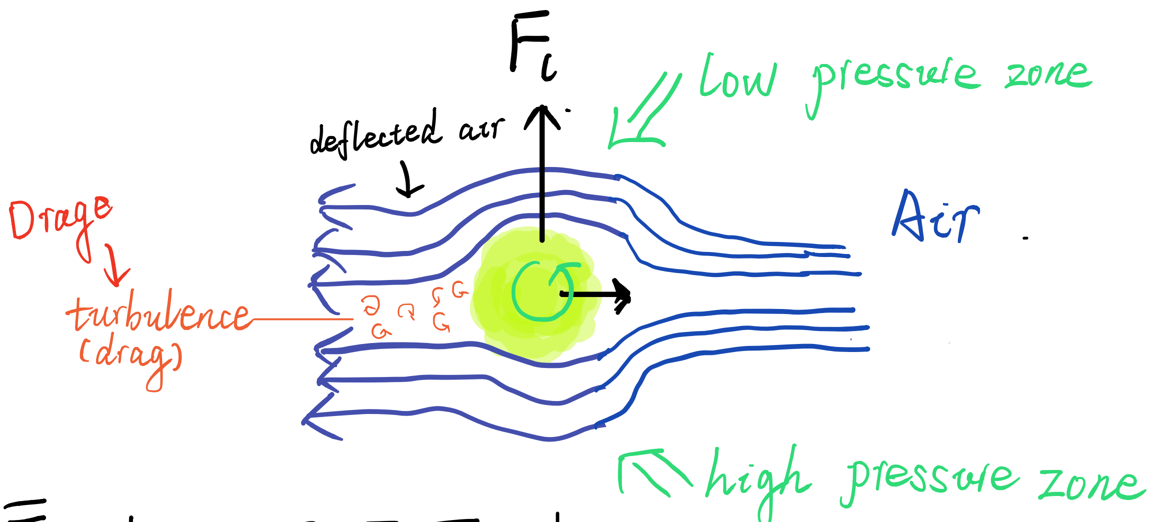
Model of the flying Ball

- Three main forces

1. Gravity
2. Drag
3. Lift



- Lift Force (Magnus Force)



$$\bar{F}=\frac{1}{2}C_l\pi r^3\rho\bar{V}\cdot\bar{w}$$

note: the drag force could be neglected because it has very little effect on ball's trajectory.

and the texture of the ball is also neglected.

C_l — lift force coefficient

r — ball's radius

ρ — air density

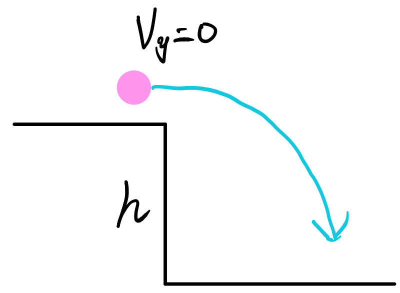
$\bar{V}$ — translational velocity

$\bar{w}$ — rotational speed

Trajectory Analysis

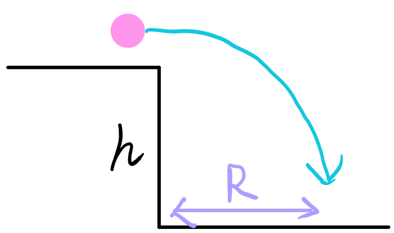
- Using the kinematic equations:

1. $V = V_0 + at$
2. $V^2 = V_0^2 + 2ad$
3. $D = \frac{1}{2}(V_0 + V)t$
4. $D = V_0 t + \frac{1}{2}at^2$



$h = \frac{1}{2}at^2$

$d = V_0 t + \frac{1}{2}at^2$

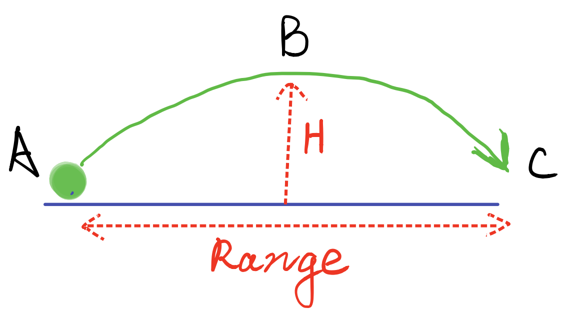


$R = V_x t$

$V_{yF} = V_{y0} + a t_y$

$V = \sqrt{V_x^2 + V_y^2}$

$\theta = \tan^{-1}\left(\frac{V_y}{V_x}\right)$



$R = V_x t$

$R = (V\cos\theta)t$

$R = V \cdot \cos\theta \cdot \frac{2V\sin\theta}{g}$

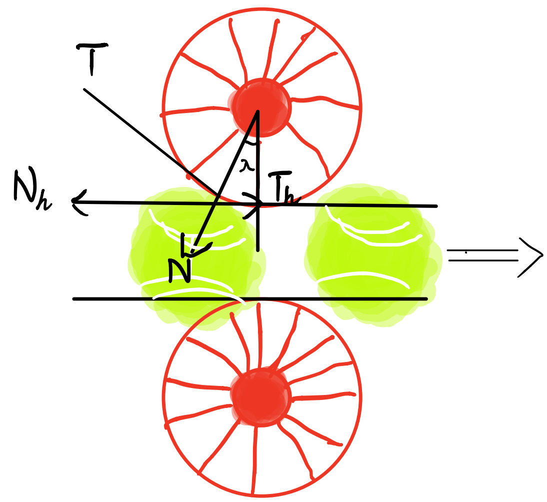
$= \frac{V^2 \cdot 2\sin\theta \cdot \cos\theta}{g}$

$\boxed{\frac{V^2 \sin(2\theta)}{g}}$

$t = \frac{V\sin\theta}{g}$

Launcher Analysis

1.1 Pulling of the ball

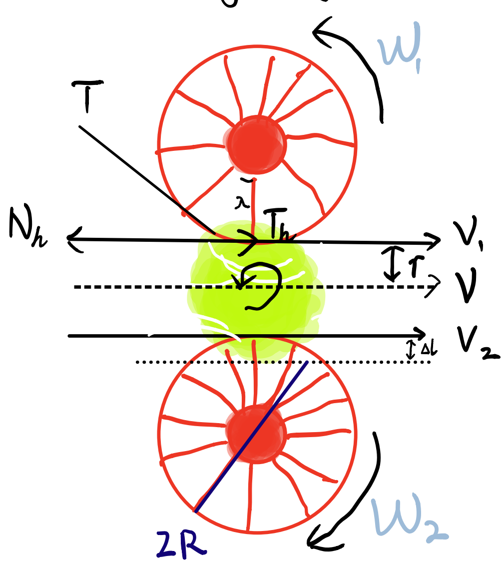


λ: Grab Angle

$T_h = N_h$ have to be equal to successfully pull the ball from the tube.

$$\boxed{T\cos\lambda \geq N\sin\lambda}$$

1.2 Rotating Speed of the Rollers and ball



Velocity:

$$V = \frac{V_1 + V_2}{2}$$

$$\omega r = \frac{V_2 - V_1}{2}$$

Rotation:

$$W_1 = \frac{V - \omega r_1}{R}$$

$$W_2 = \frac{2V}{R} - W_1$$

Conclusion:

the pressure force N and friction are kept as constants in the algorithm to simply the real world simulation of the robot.