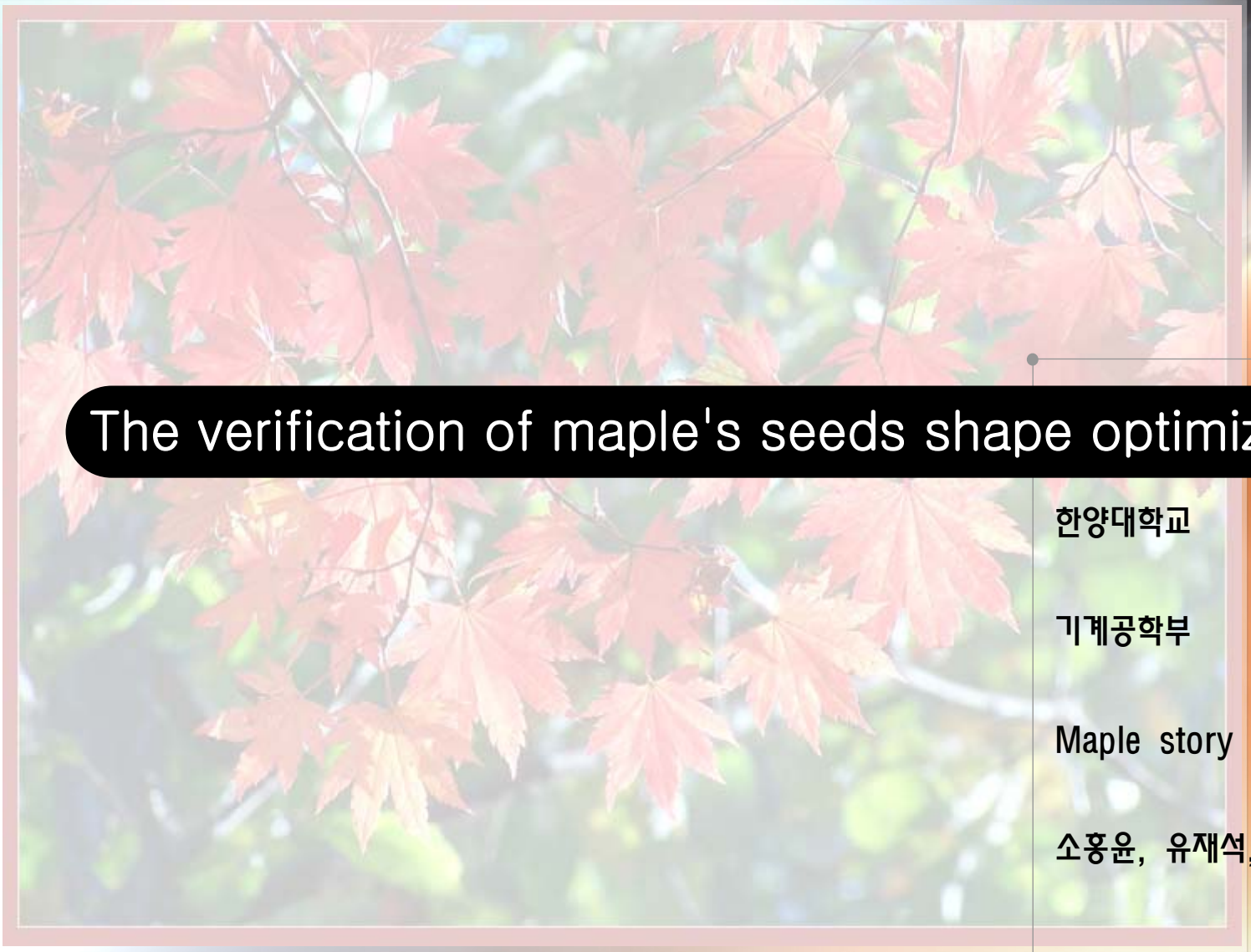


# The verification of maple's seeds shape optimized.

한양대학교

기계공학부

Maple story

소홍윤, 유재석, 고영관

## Step1 : Project/Problem Statement

- 식물은 씨앗을 퍼트리기 위해 많은 형태를 가지고 있음.

  ex) 도깨비 풀, 포자, 무궁화 꽃, 민들레, 단풍나무

- 바람에 의해 종자를 퍼트리는 대표적인 식물은 민들레, 단풍나무가 있음
- 단풍나무의 씨가 자연에 의해 최적화되었다고 가정
- 모델링을 통해 단풍나무 씨의 최적화 모양 검증

# Step2 : Data and information collection

Eqns. :

$$L = \frac{1}{2}\rho V^2 A C_L$$

$$AR(aspect\ ratio) = \frac{b}{c} \approx \frac{b^2}{S}$$

$$Attact\ angle\ (받음각)$$

$$\beta = \frac{\pi}{2} - \alpha = \frac{\alpha_0}{1 + (\frac{\alpha_0}{\pi AR})(1+\tau)} \qquad \tau : Fourier\ \ coefficient (0.05 \sim 0.25)$$

Parameters :

$$t\ (두께) = 0.4mm$$

$$w = 4mm$$

$$\rho_{air} = 1.2 \times 10^{-6}\ g/mm^3$$

$$\rho_{maple} = 15 \times 10^{-5}\ g/mm^3$$

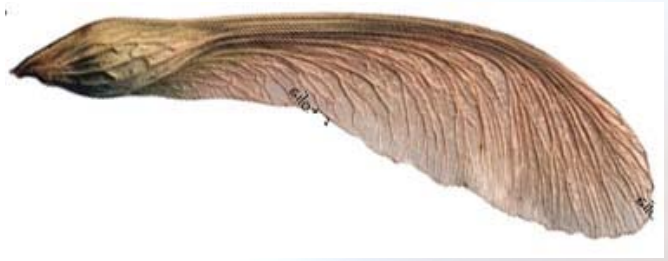
$$\alpha_0 = 0.083553 \qquad :(양력기울기 = \frac{dC_l}{d\alpha})$$

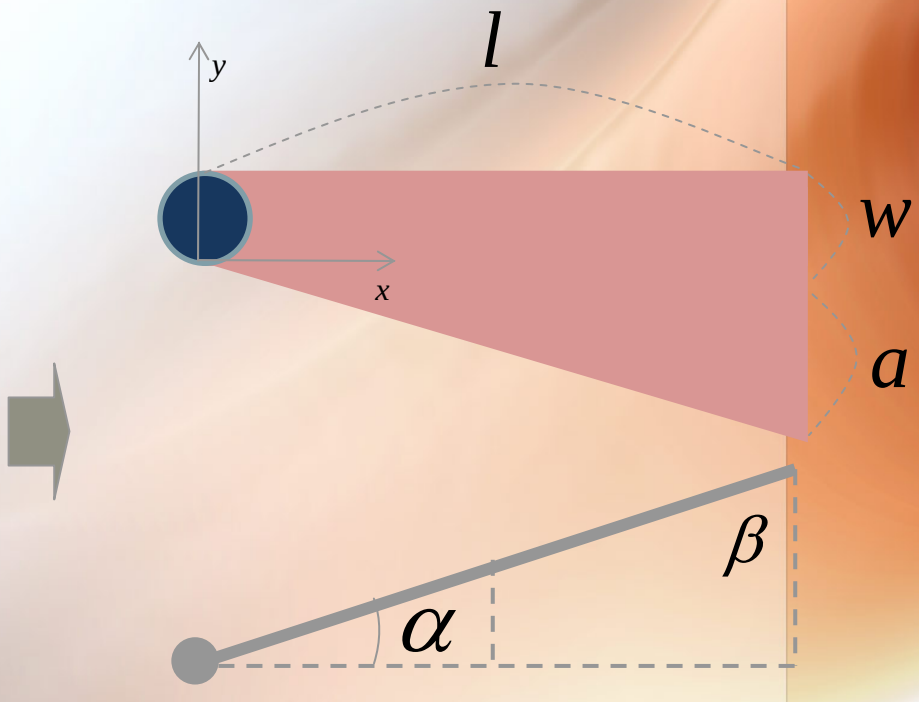
$$m = 0.03g$$

## Step3 : Identification/Definition

$a$ : 씨앗으로부터 날개 끝까지의 –y 방향의 길이

$l$ : 씨앗으로부터 +x 방향 길이





# Step4 : Identification of a Criterion to Be Optimized

Minimize : $V_{final} = f(a \ , \ l)$

종단속도:$V_{final}$

$mg = \frac{1}{2}\rho V^2 A C_L$ : 양력=중력 (종단속도 : 등속도)

$\xrightarrow{V\text{에 대해 정리하면}}$ $V_{final} = \sqrt{\frac{2mg}{\rho_{air} A C_L}} = \sqrt{\frac{2g\rho_{maple}(w+\frac{a}{2})tl}{\rho_{air}\pi l^2 \cos\alpha \times C_L}}$

| Attack angle(x) | $C_L(y)$ |
|---|---|
| 2.2 | 0.18 |
| 6 | 0.5 |
| 12 | 1.0 |
| 15 | 1.25 |

$\xrightarrow{\text{최소자승법}}$ $y = 0.083553x - 0.002768$

## Step5 : Identification of Constraints

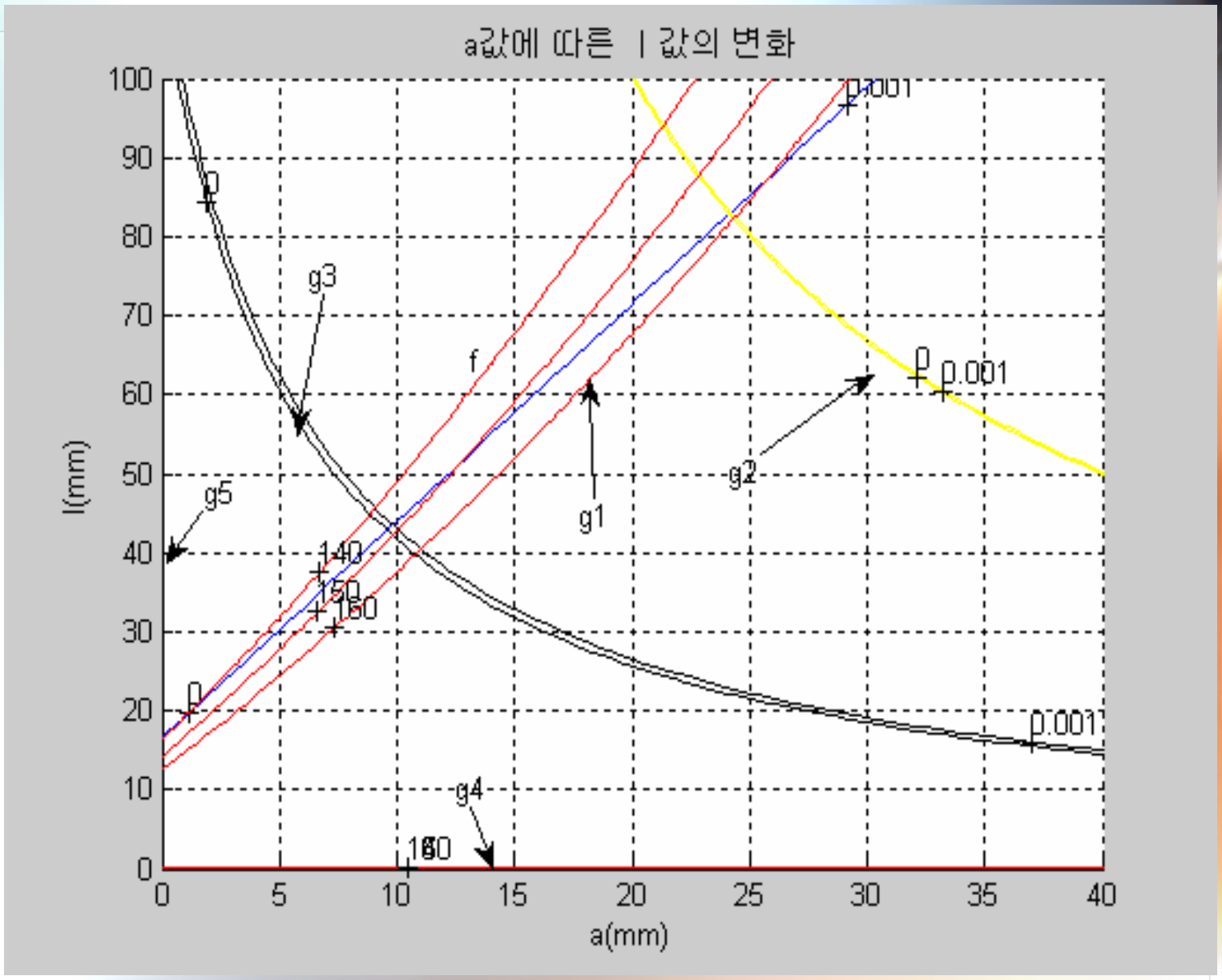
- $g1 = \dfrac{l}{w + \dfrac{a}{2}} \geq 5.5 \quad \Rightarrow \quad 5.5w + 2.75a - l \leq 0$

- $g2 = -6 \times m + \rho_{maple} tal \leq 0$

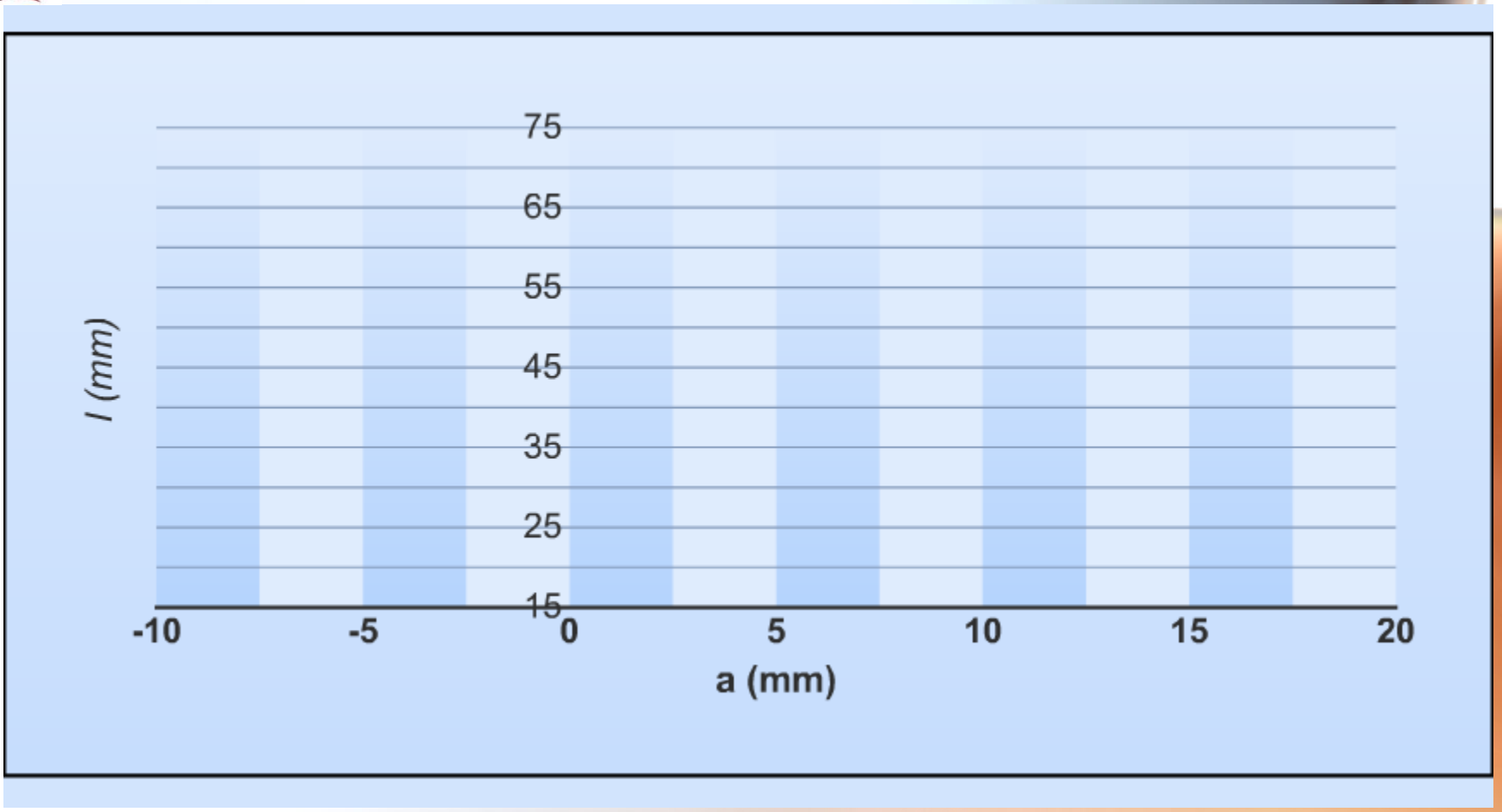
- $g3 = w\rho_{maple} tl + \dfrac{\rho_{maple} tal}{2} - m \leq 0$

- $g4 = a \geq 0 \quad \Rightarrow \quad -a \leq 0$

- $g5 = l \geq 0 \quad \Rightarrow \quad -l \leq 0$


a값에 따른 I 값의 변화
I(mm)
a(mm)
0
10
20
30
40
50
60
70
80
90
100
0
5
10
15
20
25
30
35
40
g1
g2
g3
g4
g5
f
0
0.001
140
150
160

## 2 변수



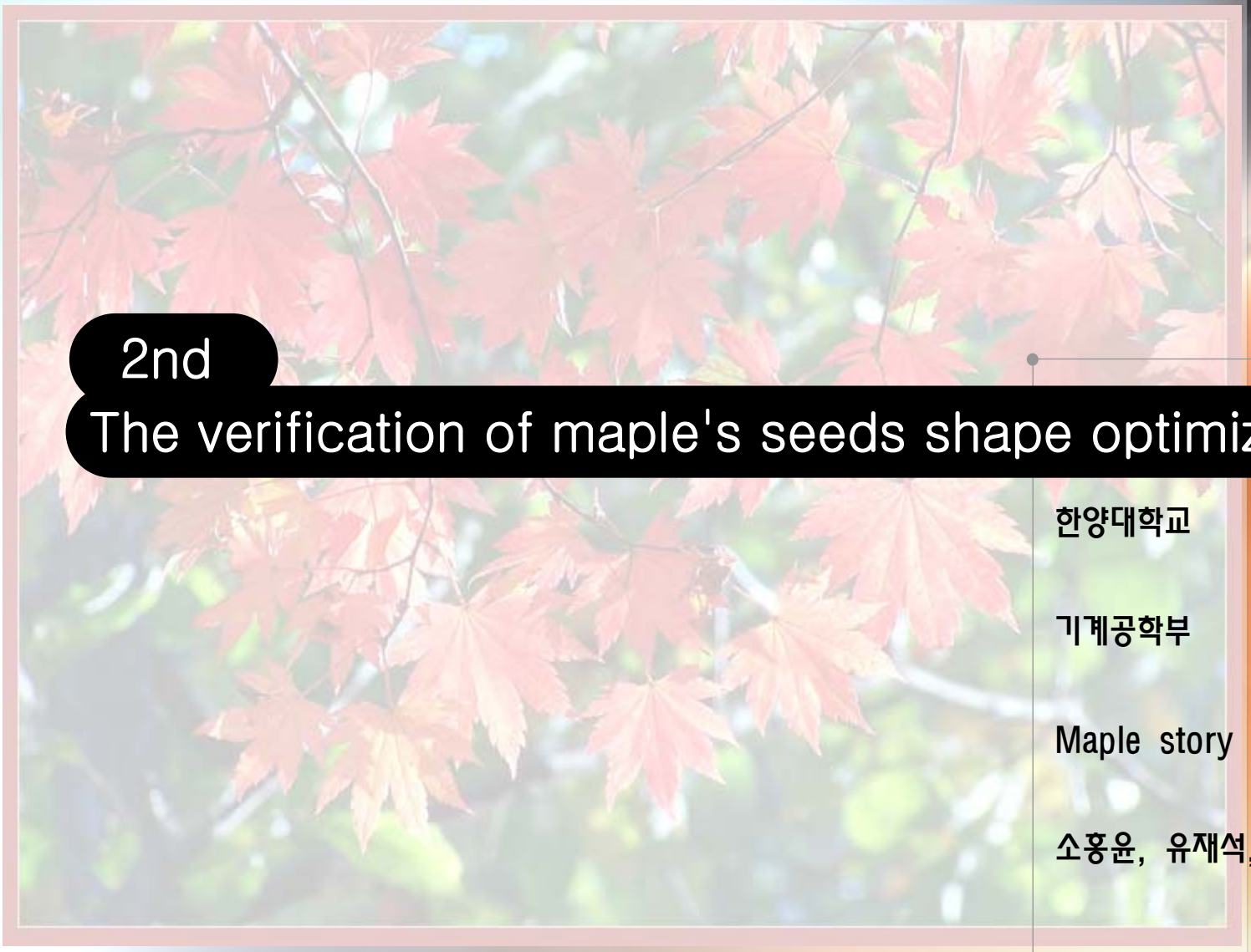

초기값

length: 20(mm)  a: 10(mm)

결과값

length: 70.463 (mm)

a: 17.623 (mm)



# 2nd
# The verification of maple's seeds shape optimized.

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Maple story

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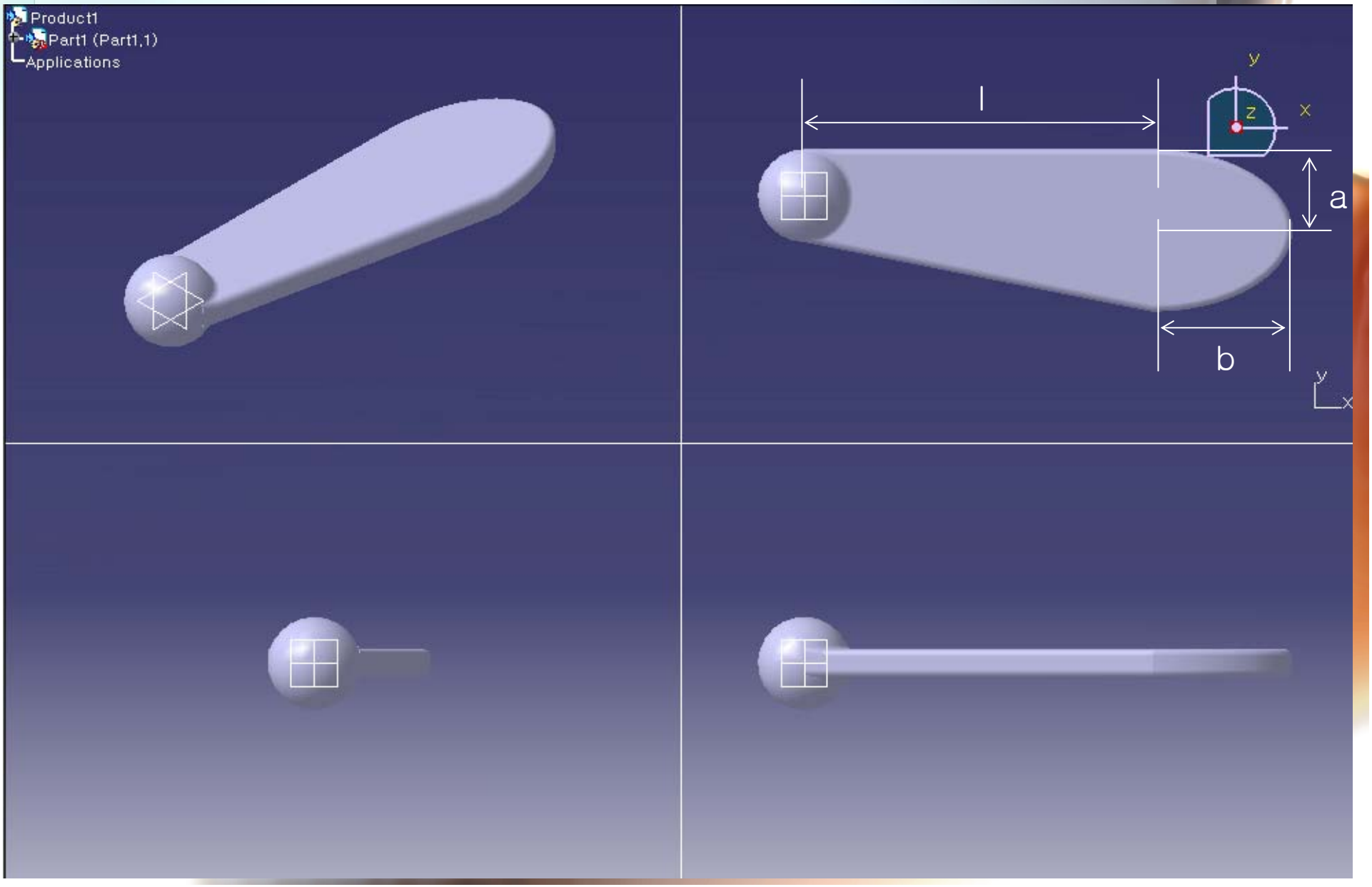
# 새로운 모델링 (3변수)



## 수정된 식

◦*AR*(종횡비)

$$AR = \frac{(l+b)^2}{(\frac{\pi ab}{2} + 2la - \frac{(2a-4)}{2}l)}$$

◦*A*(휩쓸고 지나가는 면적)

$$A = \pi(l+a)^2 \cos\beta$$

◦받음각 $\beta$

$$\beta = \frac{\alpha_0 0}{1+(\frac{\alpha_0}{\pi AR})(1+\tau)} \qquad where, \begin{cases} \alpha_0 = 0.083533 \quad (\text{양력기울기}) \\ \tau = 0.05 \sim 0.25 \\ (\textit{fourier coefficient}) \end{cases}$$

◦질량 mass

$$m = (\frac{\pi ab}{2} + 2la - \frac{(2a-4)}{2}l)\ \rho\ t$$

◦*Dragforce coefficient* $C_L$

$$C_L = 0.083553\beta - 0.002768$$

## 수정된 식

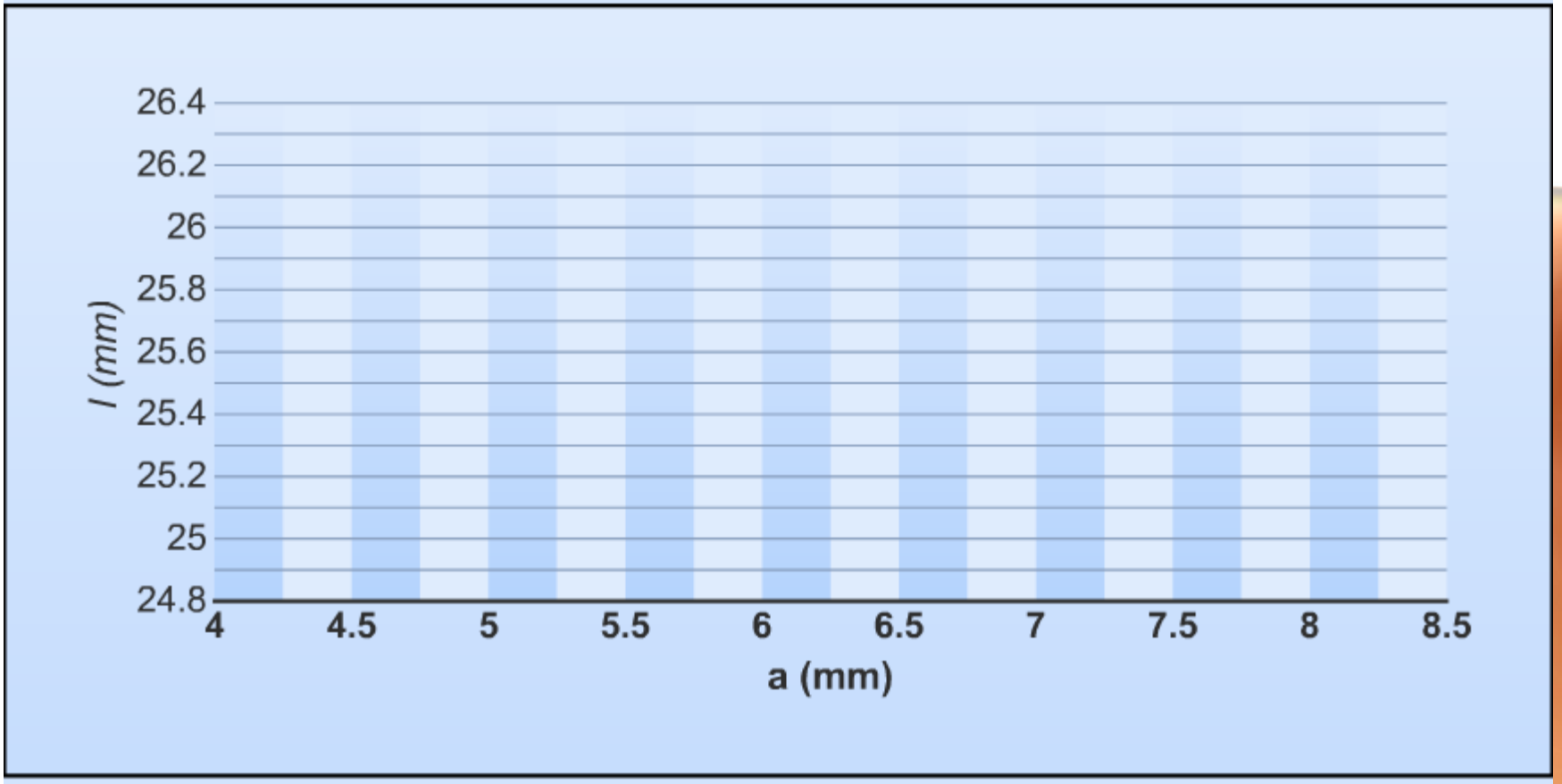
◦*Obective fucntion*

$$V_{final} = \sqrt{\frac{2mg}{\rho_{air} A C_L}}$$

◦*Constrain*

$$\begin{cases} g_1 = \dfrac{(l+b)^2}{(\dfrac{\pi ab}{2} + 2la - \dfrac{(2a-4)}{2} l)} \geq 5.5 \quad (\text{종횡비}) \\ g2 = \dfrac{\rho_{maple}(l-b)2at \times (l-b)/2 + \rho_{maple} ab\pi tl}{\rho_{maple} t(\dfrac{\pi ab}{2} + al + \dfrac{kl}{2})} \leq \dfrac{l}{2} \quad (\text{질량중심의 위치 제한}) \\ g3 = \rho_{maple} t(\dfrac{ab\pi}{2} + al + \dfrac{kl}{2}) - m \leq 0 \quad (\text{씨앗의 무게} \geq \text{날개의 무게}) \end{cases}$$

# 3 변수 (Excel-Solver)




초기값

length: 25(mm)

a: 8(mm)

b:5(mm)

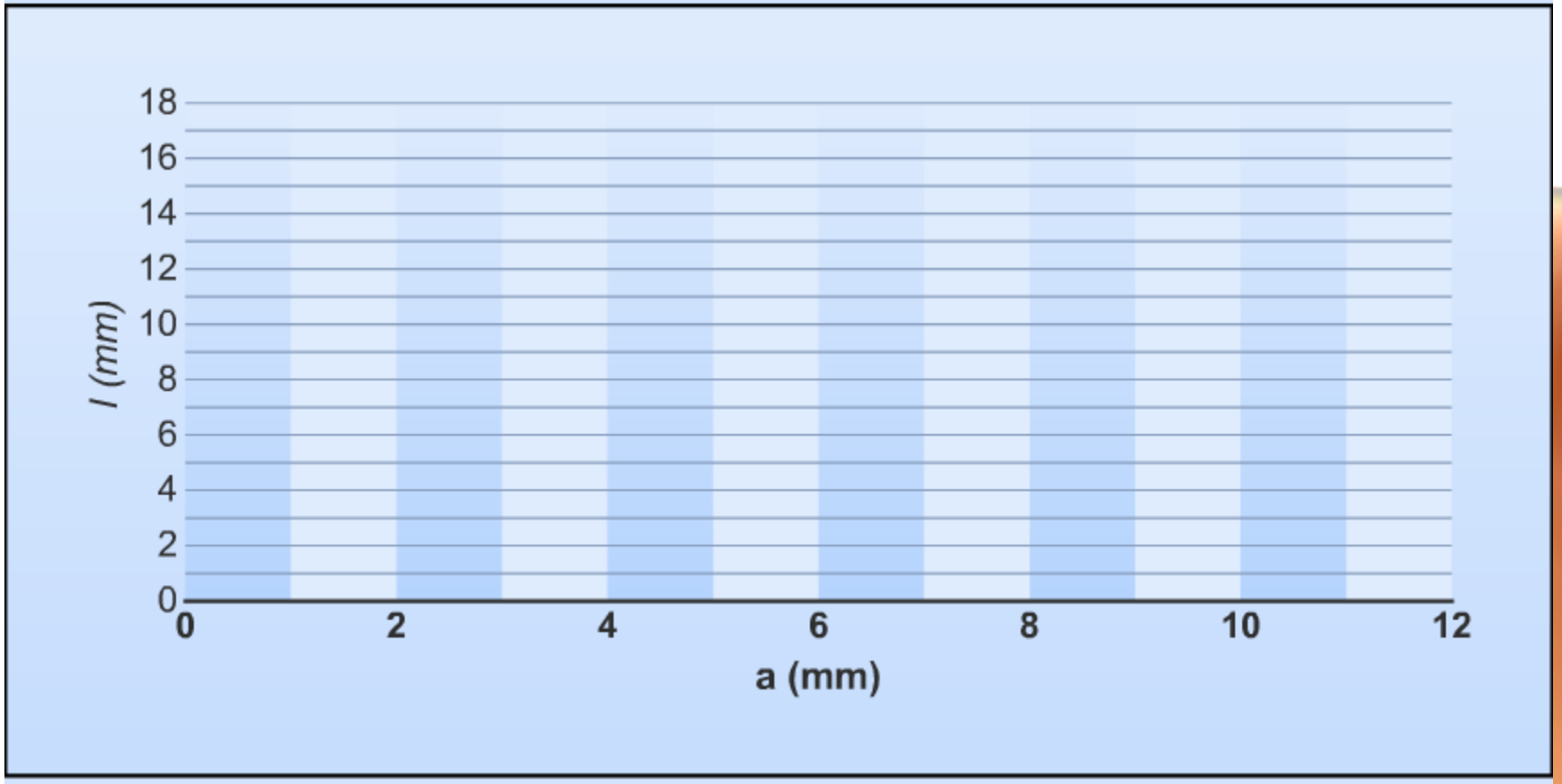
결과값

length: 26.2452(mm)

a: 5.2898(mm)

b: 15.96013(mm)

# 3 변수 (Excel-Solver)




초기값

length: 10 (mm)

a: 10 (mm)

b: 6 (mm)

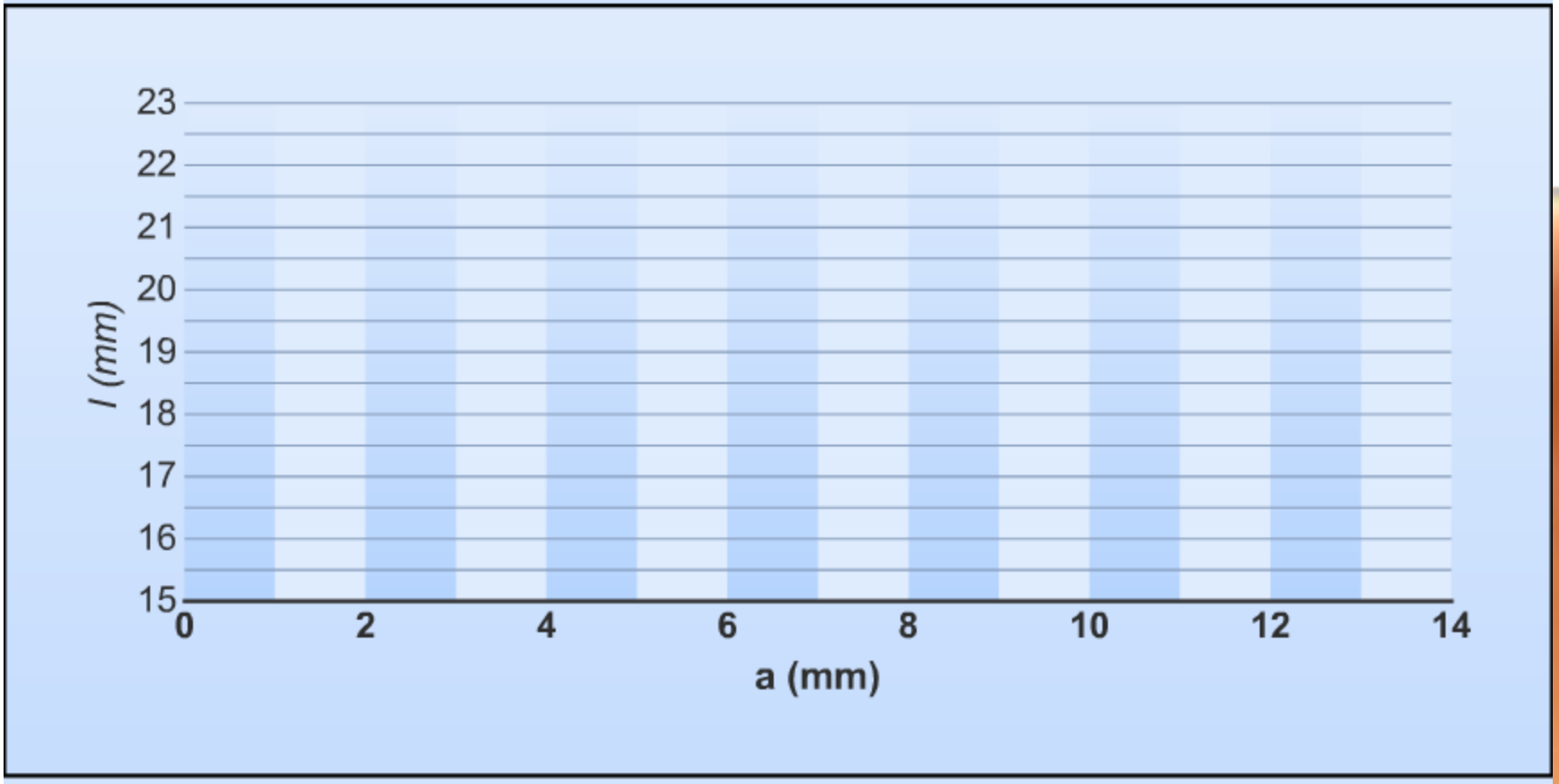
결과값

length: 13.3125246 (mm)

a: 2.05244570l (mm)

b: 7.3516439 (mm)

# 3 변수 (Excel-Solver)




초기값

length: 17 (mm)

a: 13 (mm)

b: 15 (mm)

결과값

length: 21.71587 (mm)

a: 4.915140445 (mm)

b: 18.33579 (mm)

# 모델링에 의한 결과

결과값
length: 26.2452(mm)
a: 5.2898(mm)
b: 15.96013(mm)

결과값
length: 13.3125246 (mm)
a: 2.05244570l (mm)
b: 7.3516439 (mm)

결과값
length: 21.71587 (mm)
a: 4.915140445 (mm)
b: 18.33579 (mm)

결과값
length : 5.28860
a : 1
b : 3.44196

## 실제 단풍나무 씨앗의 표본 추출

| l | a | b | l/a | a | b/a |
|---|---|---|---|---|---|
| 13.6 | 2.8 | 7 | 4.867 | 1 | 2.5 |
| 9.3 | 1.5 | 4 | 6.2 | 1 | 2.67 |
| 12 | 2 | 4.7 | 6 | 1 | 2.35 |
| 11 | 2.7 | 7.7 | 4.07 | 1 | 2.85 |
| 9.6 | 2 | 5.4 | 4.8 | 1 | 2.7 |
| 10.9 | 2.7 | 7.8 | 4.04 | 1 | 2.89 |
| 12.3 | 2.3 | 5.8 | 5.047 | 1 | 2.52 |
| 9.2 | 1.7 | 5.8 | 5.4 | 1 | 3.41 |
| 11.9 | 2.2 | 7 | 5.4 | 1 | 3.2 |
| 8.7 | 1.6 | 5 | 5.44 | 1 | 3.125 |

| 평균 | 5.1554 | 1 | 2.82 |
|---|---|---|---|