**Flight Design Project 2**
**Wing dynamics**

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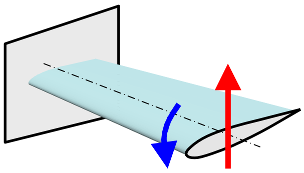
## Introduction

- For details see PDF: **Flight Project 2 – Wing dynamics**
- Evaluate and assess properties of your design:
  - Stiffness,
  - (Fundamental) natural (or "resonant") frequency,
  - Validate your predictions (using smart phone!)
- Prepare brief technical discussion on this topic:
  - Between 1 and 2 A4 sides,
  - Focus on using tables, graphs, etc.

# The need for dynamic properties of wings

http://www.youtube.com/watch?v=aE4pBmZrriU&feature=related

**Highly elastic designs**

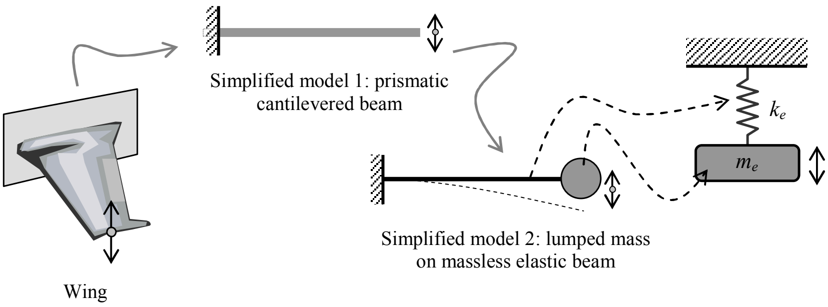


**Destructive aero-structural interaction:**

- **flutter,**
- **divergence,**
- **excessive vibrations,**
- **…**



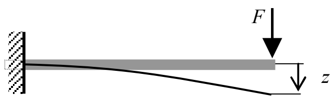
# Natural frequency of a simple spring-mass oscillator

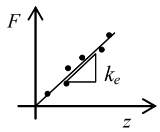



$$f_0 = \frac{1}{2\pi}\left(\frac{k_e}{m_e}\right)^{1/2} \qquad [Hz]$$

# Stiffness of your wing

**… for your specific constraint and loading conditions!!!**




**Stiffness is defined for this configuration as follows:** $F = k_e\, z$

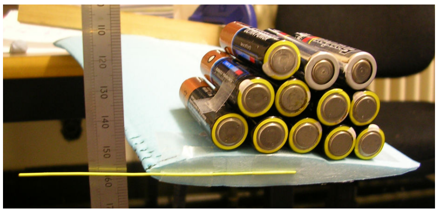
**… or differently:** $stiffness = \dfrac{applied\ load}{deformation}$

**Can you relate the above formulas to the following classical formula for the tip loaded cantilevered beam?**

$$z = \frac{F\,L^3}{3EI}$$



# Find your stiffness experimentally



**For example: 6 loads × 3 locations**

| Units! | z [?] | F [?] |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| … | | |
| | | |

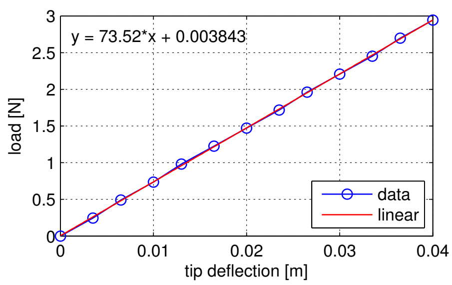
$k_{e,1}$

| Units! | z [?] | F [?] |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| … | | |
| | | |

$k_{e,2}$

| Units! | z [?] | F [?] |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| … | | |
| | | |

$k_{e,3}$



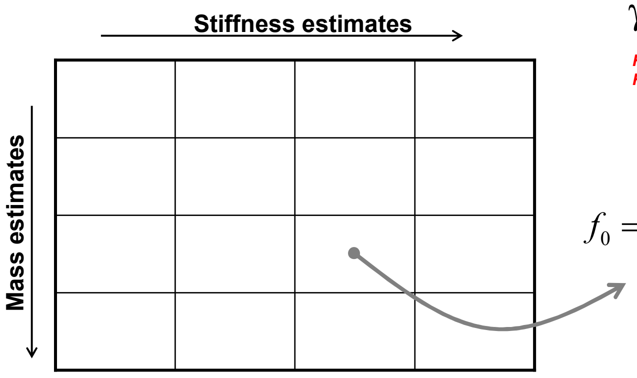
# Calculate your natural frequency

**Equivalent mass of a wing:** $m_e = \gamma\, m_{wing}$

$\gamma \approx 0.24$

$\gamma \in [0.23, 0.33]$

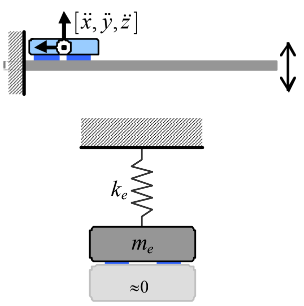
*For more details see FDP – Dynamics note*

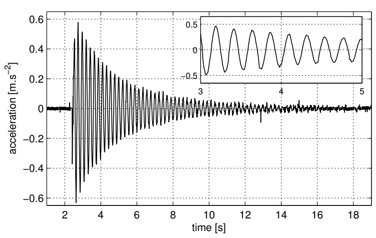


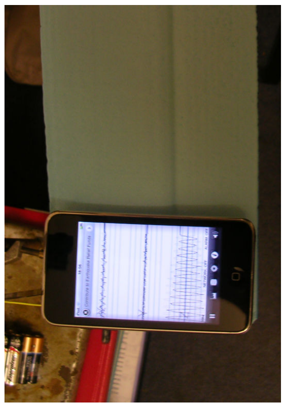

$$f_0 = \frac{1}{2\pi}\left(\frac{k_e}{m_e}\right)^{1/2}\ [Hz]$$



# Assess (and validate) your predictions



For example (my results):
$f_{exp}$=18.6 Hz
$f_{model}$=17.57 Hz (γ=…)
Error=-5.5 % etc. etc.