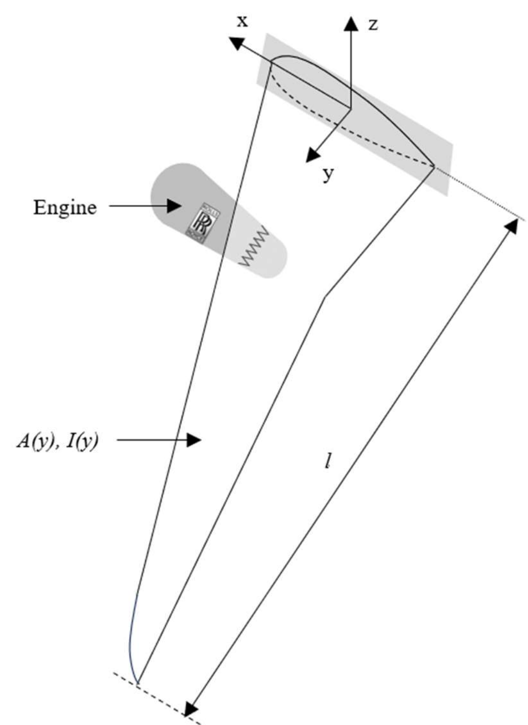
CA 2: Frequency and Mode Shape Using Ritz Method (20%)

Consider the bending vibration of a wing with Young's modulus $E = 2 \times 10^{11}$ N/m^2, density $\rho = 1600$kg/m^3 and length $l = 30$m. Cross sectional area A and second moment of area I are given as

$$A(y) = -60.78\left(\frac{y}{l}\right)^3 + 121.16\left(\frac{y}{l}\right)^2 - 79.624\left(\frac{y}{l}\right) + 19.344\ [\mathrm{m}^2]$$

$$I(y) = 2.7462 * exp\left(-7.958\left(\frac{y}{l}\right)\right)\ [\mathrm{m}^4]$$

An engine is installed at location y with mass m.



Task 1: Answering basic questions

a. What is a possible aircraft model that has this wing?
b. What is the value of y for the engine location?
c. What is the mass of the engine for this aircraft?
d. What are the assumptions for the assembly to only undergo pure bending vibration?
e. What are some of the methods to increase the resonant frequency of the wing?

Task 2: Using Ritz method, what are the first four natural frequencies and associated mode shapes (Plot modes shapes on the same figure)?

Students should use the assumed shape function covered in class. Students need to first determine how many terms is needed to be included in order to obtain better than 1% accuracy. You can try increasing values of n until the computed value of 4th natural frequency virtually does not change (converged results).

Task 3: If the engine is removed, how will the first four natural frequencies and mode shapes change? [Students should create a new figure and then plot both mode shapes together for comparisons to be made]

CA 3: Other assumed shape functions (10%)

Task 4: Include a flow-chart of how your code is structured in Task 2.

Task 5: Attempt Task 2 of CA2 using assumed shape functions apart from the one covered in class.

You will need to submit a **report** addressing this CA. Please **upload report and the code to NTULearn where there will be checks on plagiarism. Please upload the report in Microsoft Word format.** Your report should be presented in the following order: Chapter 1: Your answers to Task 1 | Chapter 2: Your approach to Task 2. Include key equations used, the final assembled matrices from Matlab for the largest n used, results, discussions, plots, etc. | Chapter 3: Your answers to Task 3. | Chapter 4: Your answers to Task 4 | Chapter 5: Your answers to Task 5 which is a repeat of Chapter 2 for the portions you feel necessary. | Chapter 6: Conclusions (if any) | Chapter 7: Declaration of honesty (declare what help you have obtained or where you have obtained help from. Name of friends, ChatGPT, etc,) and what help are obtained | Appendix: Copy and Paste all your codes here.

General approach for using Matlab

- General approach
  - *f.* *Clear all* *% remove all stored info*
  - *g.* *Constants* *% define the constants*

    E =…

    rho_f = …
  - *h.* *Assemble matrices using for loop, the functions and integration*
  - *i.* *Find eigenvalues*
  - *j.* *Analyse and Plot results*

- To form a matrix – use **for** loop.

```
n = XX                          % number of modes to keep
for i = 1:n
    for j = 1:n
        M(i,j) = XXXX
        K(i,j) = XXXXX
    end
end
```

- To perform integration, you may use

```
syms x
fun = x/(1+x^2);
M(i,j)  = int(fun,x,xmin,xmax)
```

or

```
fun = @(x) x+x.^2+x.^3;
M(i,j)  = integral(fun,xmin,xmax)
```

  where *fun* is the function with respect to *x, with xmin* and *xmax* the limits of integration

- To find eigenvalues, use *[V,D] = eig(A)* returns diagonal matrix *D* of eigenvalues and matrix *V* whose columns are the corresponding right eigenvectors, so that *A*V = V*D*.
  Please also sort your eigenvectors (mode shapes) according to the eigenvalues to obtain the correct shapes.
  You also need to multiply the eigenvector with assumed shapes to obtain the actual modeshape
- You may see entries of the matrices to be long numbers with division. Use X = eval(X) to evaluate these numbers
- You may need to substitute values into variable of the equations, use X = subs(equation, y, number)
- To plot an equation, use fplot(equation,[0, L])
- For plotting of two vectors x and y, use *plot(x,y,'color')*
- To multiply assumed modes with the eigenvectors. The following function could be useful