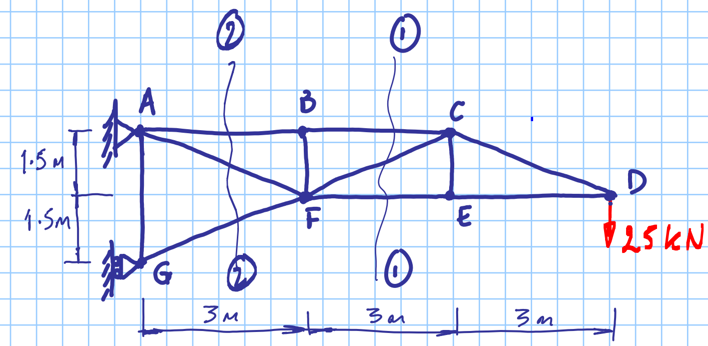
StM1 B(ii) Assignment 2017-2018 Solution Guide

Note Title

JCF

20/03/2018

Q1

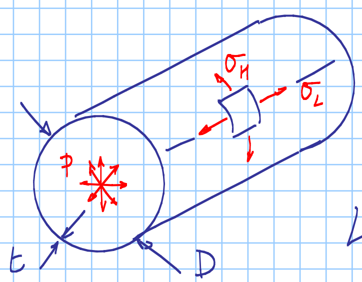


To find element most prone to buckling.

- Deduce element most likely to be loaded in compression
  - by inspection! Sense of load? Length? Find L_i, P_i
- Find min 'I' of critical element to avoid Euler buckling, i.e. for $P^*_{crit} \geq P$
- Find min thickness hollow section given OD = 75 mm to achieve reqd I value

  Assumption - thin or thick wall? Check RF for designed tube → $\boxed{RF=}$
- Yielding: check $\sigma < \sigma_y^*$ → $\boxed{RF=}$

Q2

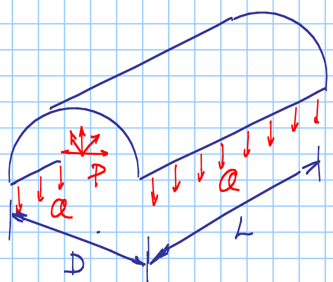


p = bar → N/mm² or MPa.

Lengthwise lap joint will carry tensile hoop load

Consider as a loading intensity 'q' i.e. load/unit length.

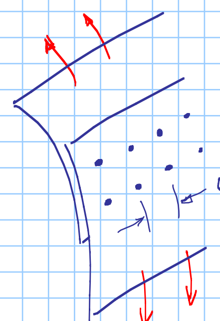
FBD:



Equilib'm $\Sigma\uparrow = 0$:

$\hookrightarrow$ $q =$ N/mm

Let rivet pitch = w and assume each row carries half the load



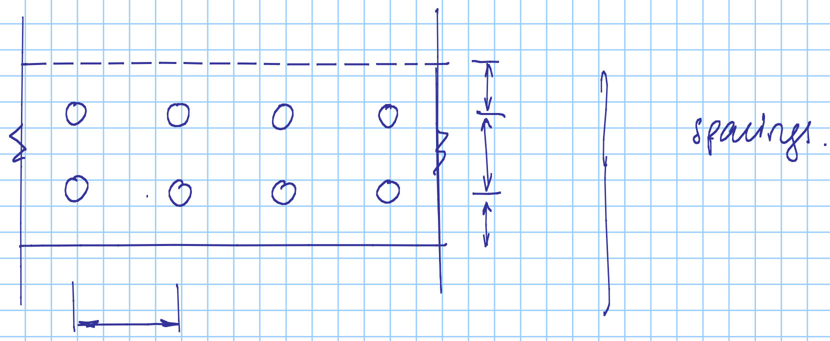
Load on each rivet $= \frac{q}{2} \times w$ ← (two rows)

Using ϕ 4mm L37 rivets Aero h/b → Single shear strength S^*

Design for Load at ultimate not to exceed rivet shear strength

Noting spacing guidelines. Perform trials. Work in N, mm. check

Aiming for RF = 2 → $\boxed{RF =}$



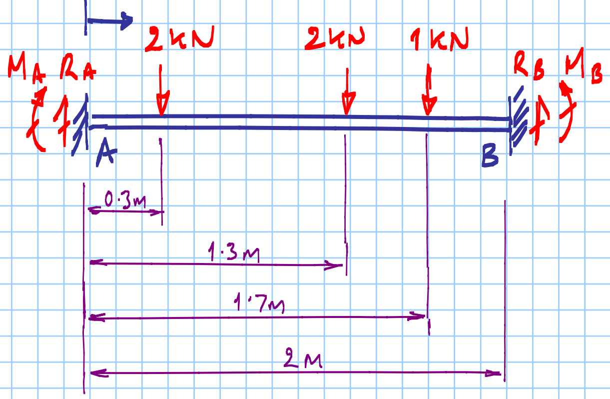
Check other modes.

Q3

Fixed ends and UDL Loading - approximate as - Standard beam model :

Note, Limit loads given.

ie Fully fixed beam with UDL :



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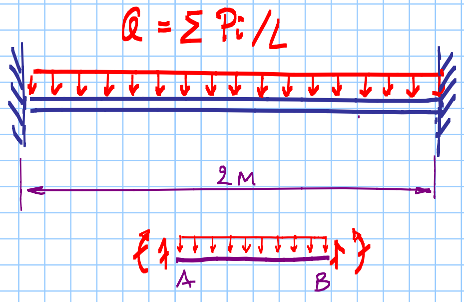
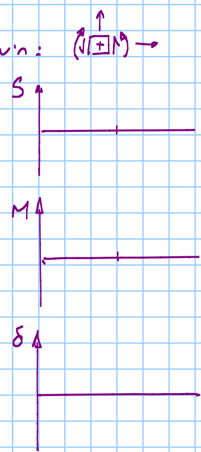


State Sign conv'n :



FROM references: or derive

$S_{MAX} =$

$M_{MAX} =$

$v_{MAX} =$

Note reversed mmt @ ends of beam

Initial Stiffness check – at limit

Using std. FF/UDL Beam formula

Design for required v_{max} not to exceed δ^* @ limit

ie. for: $v_{max} \leq \delta^*$ @ limit

From FF/UDL beam model: $k \frac{Q L^4}{EI}$ for UDL loading Q units!

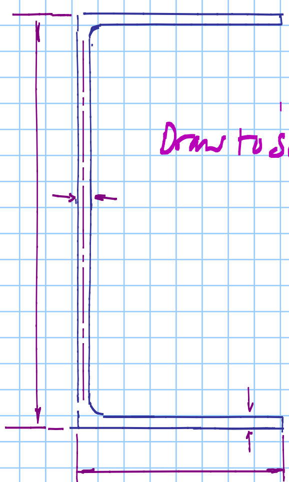
From Aero h/b: 2024 T351 alloy data: $E = \#$

↳ Solve for required I value

Next, design C section beam to achieve this value.

Trial C-beam (fixed ends):

Try: $b_w = \#$, $b_f = b_w/2$, $t_w = t_f = \#$



Draw to scale!

- Using trial dimensions allows us to gain experience of expected deflections or stress or strain values.
- Using "thin wall" approximation, i.e. neglecting 2nd order 2nd mmt of area terms, initially accounting for flanges only:

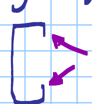
↳ $I_f \approx$

Accounting for web: $I_w =$

Total: ↳ $I \approx$

Check deflection $v =$ units!

Noting:
- 2ndary //e axis flange 2nd mmt area to be accounted
- Attachment to floor plate will reduce deflection further

Local panel buckling checks may require increased thickness and lips on flanges, ↳ i.e.  but this is not covered until AVDASI 2.

Initial strength checks - at ultimate

Using std. FF/UDL Beam formula

Check trial scheme:

STRENGTH:

Flanges: check max direct stress @ ultimate

Units: mm, N

Compare: $\sigma = \frac{My}{I}$ @ ultimate loading, where $M = M_{max}$ from beam formulae

with σ^*_{ULT} for 2024 T351 ally data from Aero h/b (assuming $\sigma_c^* = \sigma_t^*$)

→ $\boxed{RF = \quad}$

Webs: check ave' shear stress @ ult:

Compare: $\tau \approx \frac{S}{A_w}$ @ ult

with τ^*_{ULT} for 2024 T351

→ $\boxed{RF = \quad}$

Joint

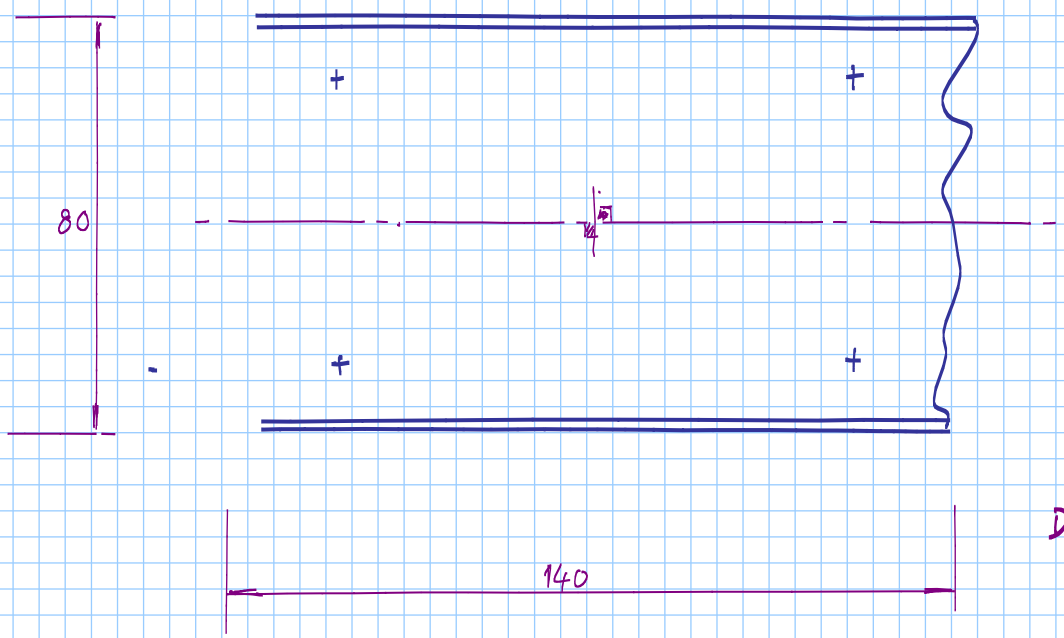
Scheme: Riveted joint - web only

Trial: N × ⌀4 mm rivets,

Arranged in an array of $N_x \times N_y$

I.e. start with a trial array that looks reasonable in the space available that also meets the spacing guidelines.

Draw to scale!



Aero h/b p4-7 guideline checks:

w/d etc.

Cluster spacing

Edge "

Dims: mm

Obtain loading from UDL beam model F_x, F_y, M end reactions

Remember, $\times 1.5 \rightarrow$ ultimate values.

Use a rivet group analysis:

Concentric loads : $P_{cx_i} = -F_x/n$, $P_{cy_i} = -F_y/n$

Eccentric " $P_{ex_i} = \dfrac{M\, r_{y_i}}{\Sigma(r_{x_i}^2 + r_{y_i}^2)}$, $P_{ey_i} = \dfrac{-M\, r_{x_i}}{\Sigma(r_{x_i}^2 + r_{y_i}^2)}$

Solve by tabulation / spreadsheet deduce rivets carrying highest loading
Check rivet shear failure mode $\rightarrow$ $\boxed{RF = \quad .}$
Check by inspection + hand calc @ highest loaded rivet

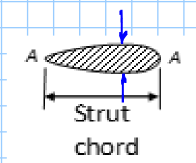
Check other modes. $\rightarrow$ $\boxed{RF = \quad .}$

Q4

Given strut length

Strut chord

Max thickness % $\Big\} \rightarrow$ thickness



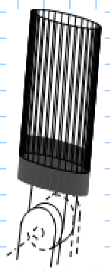
a) Strut buckling strength

Calc P_{crit} for typical hardwood modulus $E = \#$ GPa. $\leftarrow$ find!

using I = min 2nd mmt of area of strut.

Approximate shape as an ellipse

b) Double shear pin joint :



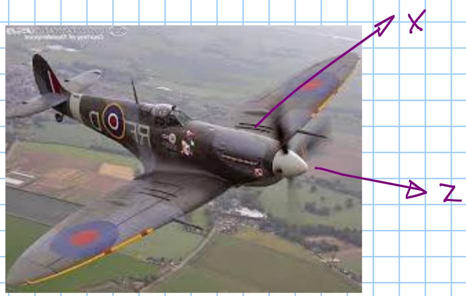
Trial scheme : pin dia: $d = \#$, inner lug thickness : $t = \#$

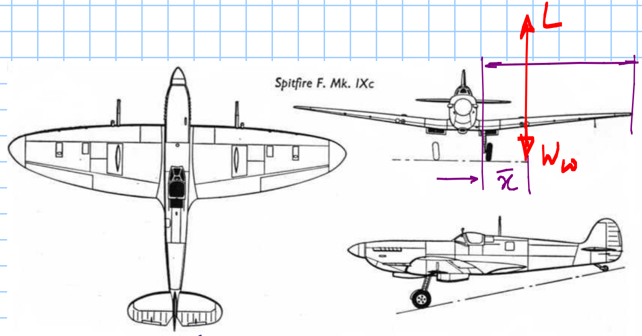
Check :

Pin shear $\longrightarrow$ $\boxed{RF = \quad}$

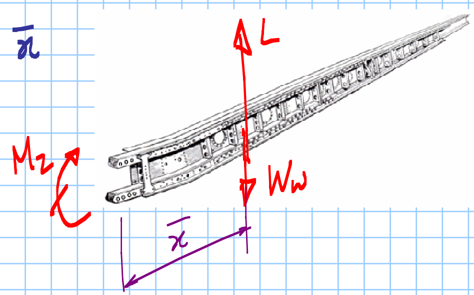
Lug bearing $\longrightarrow$ $\boxed{RF = \quad}$

Q5





Assuming 1g lift = MTOW "Max Take off Weight"
and wing weight (both) $W_w = \frac{1}{3}$ empty weight } at $\bar{x}$



a) Reactive couple carried by spar caps

Wing load $\quad F_y = n \times \frac{L - W_w}{2} \times g \quad$ at $\bar{x}$

Load factor

half load carried by each wing

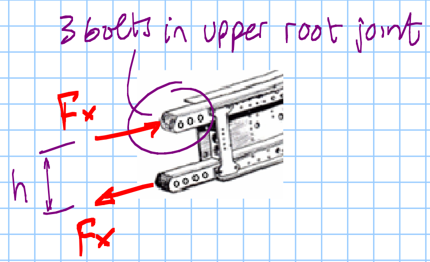
i.e. inertia relief of wing weight

↳ Root bending moment $M_z = F_y \times \bar{x} =$

Couple end load:

Equilibm: $F_x \cdot h = M_z$

$\hookrightarrow$ $F_x =$



b) Spar cap stress: σ c/w σ^* $\rightarrow$

RF =

c) Bolt shear $\tau =$ c/w τ^* $\rightarrow$

RF =

Spar cap bearing σ_{br} c/w σ_{br}^* $\rightarrow$

RF =