UNIVERSITY OF BRISTOL
FACULTY OF ENGINEERING

First Year Examination for the Degrees of
Bachelor and Master of Engineering

MAY/JUNE 2015	3 Hours

STRUCTURES AND MATERIALS 1A

AENG11200

This paper contains *seven* questions, *five* in Section A and *two* in Section B.

Answer *five* questions.

You must answer Q1 and *four* other questions.
At least one question must be chosen from Section B

All questions carry *20 marks* each
The maximum for this paper is *100 marks*

TURN OVER ONLY WHEN TOLD TO START WRITING

SECTION A

Q1 This question is compulsory and consists of 20 short answer questions which should all be attempted. Answers should be no more than one or two sentences.

(20 marks, 1 for each short answer question answered correctly)

(a) Name the four main structural components of a wing box structure.

(b) Why do polycrystalline metals have higher yield strengths than single crystals?

(c) What are the three common crystal structures found in metals?

(d) What happens to the Euler buckling load when the length of a strut is doubled?

(e) What is a typical value of Young's modulus for an aerospace titanium alloy?

(f) Define buckling failure.

(g) Define the yield stress of a material and suggest a typical alloy that it may apply to.

(h) What is the ratio of Hoop stress to longitudinal stress in a thin wall pressure vessel?

(i) Where would you find the maximum bending stress in a beam with uniform cross-section?

(j) For typical engineering alloys which is larger, strength or Young's modulus?

(k) Name three arguments that can be applied to solve a statically indeterminate structure.

(l) What is the difference between brittle and ductile failure?

(m) What is viscoelasticity?

(n) Why are ceramics brittle?

(o) Define ultimate load.

(p) Define proof load.

(q) Define limit load.

(r) Write the parameter product that represents torsional rigidity and name the terms.

(s) Write the Engineers' beam bending relationship and define the parameters in it.

(t) Define "homogeneous", "isotropic" and "linear" as applied to describe material properties.

Q2 Part of an undercarriage leg structure is idealised as shown in Figure Q2 and is subjected to a sideways load $\boldsymbol{F}$ at D. The joints A, C and E can be assumed to act as pin joints. The connection between element BC and ABD can be assumed to be rigid.

(a) Calculate the reactions at A and E.

(6 marks)

(b) Sketch carefully the distributions of shear force and bending moment along the member ABD. Give principal values and ensure that these are reasonably scaled in your sketch.

(12 marks)

(c) State any assumptions made.

(2 marks)

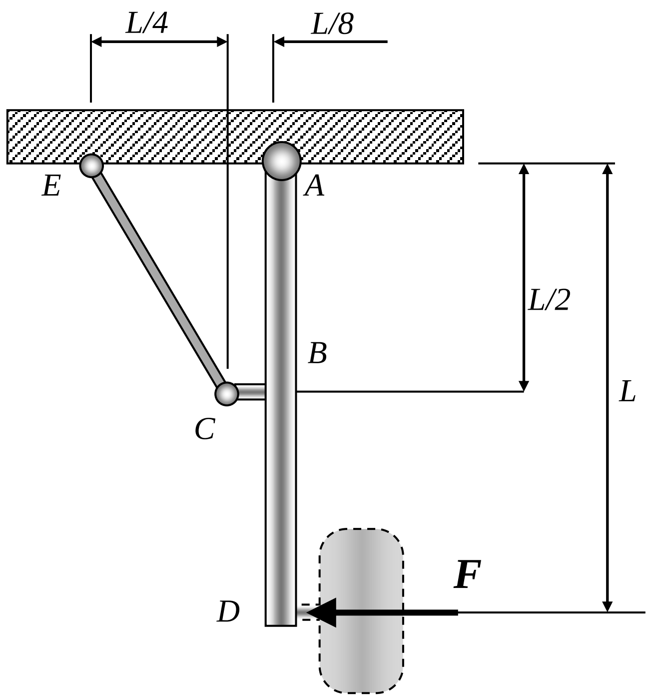


Figure Q2

turn over…

Q3 Figure Q3 illustrates a hollow circular tube of outer diameter 70mm, inner diameter 60mm, welded at the left hand end, *A*, to a rigid end plate and at the right-hand end, *B*, to a fixed plate. A solid circular bar of diameter 40mm is fixed inside the tube and is concentric with it. The bar passes through a hole in the fixed plate at *B* and is welded to the end plate of the tube at *A*. The bar is 1.0m long and the tube is 0.5m long. Both the bar and the tube are made of an aluminium alloy with a Young's modulus E = 70GPa and a shear modulus G = 27GPa. The Polar 2nd moment of area of a solid shaft can be taken as $\pi D^4/32$. Consider two separate loading cases (a) and (b):

(a) A torque $\boldsymbol{T}$ = 1000Nm acts at the end *C* of the bar.

(i) Determine the maximum shear stress in both the bar and the tube.

(4 marks)

(ii) Determine the angle of twist (in degrees) at end *C* of the bar relative to the fixed plate at *B*.

(4 marks)

(iii) State any assumptions made.

(2 marks)

(b) In a separate loading case an axial pulling load, $\boldsymbol{F}$ = 20kN is applied to the end of the bar at *C*.

(i) Determine the direct stress in both the bar and the tube

(4 marks)

(ii) Determine the deflection of end *C* of the bar relative to the fixed plate at *B*.

(4 marks)

(iii) State any assumptions made.

(2 marks)

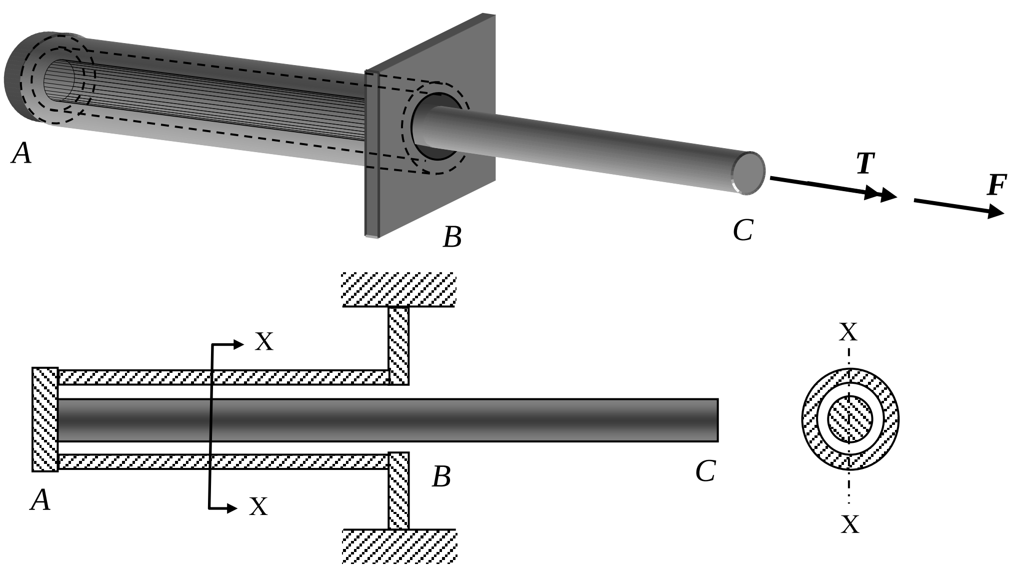


Figure Q3

Q4 Figure Q4a and Figure Q4b illustrate a rotor blade root joint consisting of a bolted double-pin, double-shear connection. The joint is subjected to an ultimate axial load of 80 kN which can be assumed to be carried equally by both bolts. Given the rotor-lug and bolt properties below, check all the possible modes of failure in the rotor-lug and the bolts and quote the ultimate reserve factors. The mating double shear hub-lugs can be assumed to be covered by the rotor-lug checks here. Comment on your results.

(20 marks)

Bolt allowable design values:

- Shear ultimate strenth = 517 N/mm^2
- Tensile ultimate strength = 1250 N/mm^2
- Bearing ultimate strength – assume larger than lug allowable value

Rotor-lug allowable design values:

- Tensile ultimate strength = 440 N/mm^2
- Shear ultimate strength = 255 N/mm^2
- Bearing ultimate strength = 660 N/mm^2

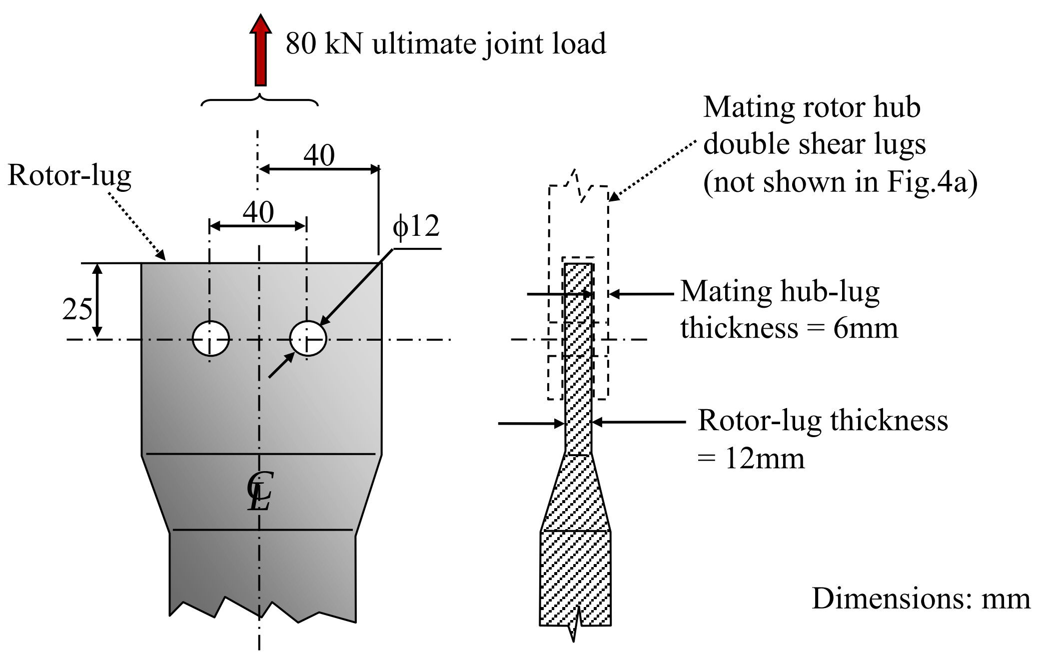


Figure Q4a **Figure Q4b**

turn over…

Q5 (a) A transport aircraft with two fuselage mounted engines has a wingspan of 40 m. The mass of the wing structure is 10,000 kg and the wing also carries 20,000 kg of fuel. The all-up mass of the aircraft is 100,000 kg. For simplicity the distribution of structural mass, fuel mass and lift may all be assumed to be uniform across the span. It may be assumed that there is no tail loading. Loads from the fuselage may be assumed to be transmitted at points 2 m either side of the midspan position. Draw the shear force and bending moment diagrams for a symmetric manoeuvre case with a load factor of 2.5, giving the principal values in each case.

(10 marks)

(b) If the engines were mounted on the wings rather than on the fuselage, explain qualitatively what the effect would be on the wing loading for this case, with all other parameters being as before. Show schematically the effect on the shear force and bending moment diagrams.

(5 marks)

(c) Explain the structural functions of wing ribs and make a labelled sketch of the typical construction of a rib for a transport aircraft.

(5 marks)

SECTION B

Q6 (a) What are the factors which determine the strength of composite materials?

(3 marks)

(b) Carbon fibres provide longitudinal fibre reinforcement to a nylon thermoplastic material subject to a tensile load. If the volume fraction (V_f) of carbon fibres is 60%, what is the modulus of elasticity of the carbon/nylon composite along the direction of alignment of carbon fibres, given the moduli of carbon fibres and nylon as: $E_{carbon} = 210$ GPa and $E_{nylon} = 2.8$ GPa.

(5 marks)

(c) With the help of a schematic diagram explain what an edge dislocation is. What happens to dislocations at the yield point of a metal?

(4 marks)

(d) Draw a schematic representation of the stress-strain curve you would expect to obtain from a tensile test on a metal specimen at room temperature. Identify and define the key mechanical properties which you could determine from the data.

(8 marks)

Q7 (a) Compare the advantages and disadvantages of thermoset over thermoplastic polymers

(4 marks)

(b) What is the difference between an interstitial and a substitutional alloy? Explain how alloying can increase the strength of metals.

(5 marks)

(c) Describe and illustrate the basic crystal structure of a face centred cubic (FCC) lattice and a body centred cubic (BCC) lattice. How many atoms are present in a unit cell of an FCC lattice and in a unit cell of BCC lattice?

(6 marks)

(d) Name the different type of chemical bonds and briefly explain the nature of each type.

(5 marks)

StM1
June 2015
Solutions!

Q1 This question is compulsory and consists of 20 short answer questions which should all be attempted. Answers should be no more than one or two sentences.

(20 marks, 1 for each short answer question answered correctly)

(a) Name the four main structural components of a wing box structure
Covers, spars, ribs, stringers

(b) Why do polycrystalline metals have higher yield strengths than single crystals?
mechanical integrity must be maintained at grain boundaries

(c) What are the three common crystal structures found in metals?
FCC, BCC, HCP

(d) What happens to the Euler buckling load when the length of a strut is doubled?
÷ 4

(e) What is a typical value of Young's modulus for an aerospace titanium alloy?
110 GPa

(f) Define buckling failure
Buckling = instability leading to increasing bending deflection

(g) Define the yield stress of a material and suggest a typical alloy that it may apply to.
Yield stress σ_y defines the elastic limit and onset of yielding when the transition is pronounced . Typical of some steel alloys.

(h) What is the ratio of hoop stress to longitudinal stress in a thin wall pressure vessel?
2:1

(i) Where would you find the maximum bending stress in a beam?
At the position of maximum bending moment and furthest distance from the neutral axis in the cross-section.

(j) Typically for engineering materials which is larger strength or Young's modulus values?

Y.m.

(k) Name 3 arguments that can be applied to solve a statically indeterminate structure.

Static equilibrium
Compatibility of displacements
Force-displacement (or stress strain or stiffness) relations

(l) What is the difference between brittle and ductile failure?
Ductile materials show large deformation before failure whereas brittle materials show low deformation before failure.

(m) What is viscoelasticity?
Viscoelastisity is a mechanical behaviour of certain class of materials which show combination immediate elastic recoverable deformation as well as time-dependent viscous recoverable deformation.

(n) Why ceramics are brittle?
Ceramics like metal also have large number of dislocations, however these dislocations are not free to move during application of external load, hence due to lack of dislocation movement the ceramics are brittle

(o) Define ultimate load

Ultimate load = maximum load before failure = limit load x ultimate factor

(p) Define proof load

Proof load =test load at which an acceptable level of plastic deformation is reached =limit load $\times$ proof factor

(q) Define limit load

Limit load = maximum anticipated working load

(r) Write the parameter product that represents torsional rigidity. Name the terms.

GJ, Shear modulus, Torsional constant

(s) Write the Engineers beam bending relationship and define the parameters in it.

$-\sigma / y = M / I = E/R$

(t) Define "homogeneous", "isotropic", "linear" as applied to describe material properties.

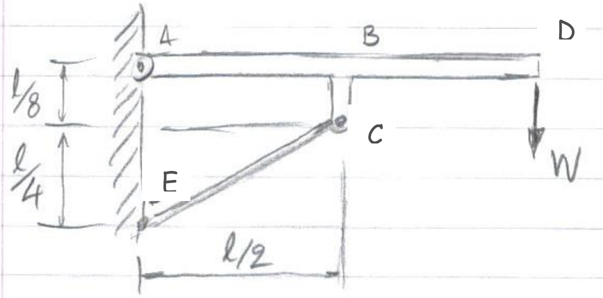
Homogeneous => properties the same at different points

Isotropic => properties same in different directions

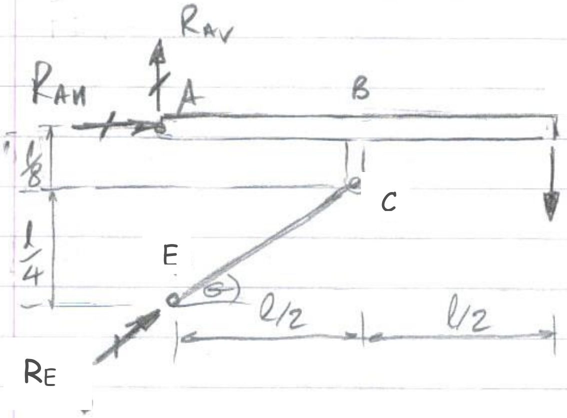
Linear => strain directly proportional to stress

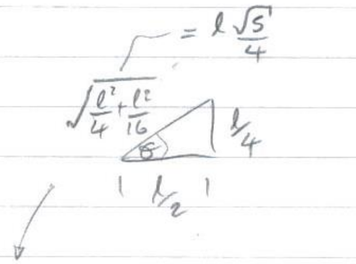
Q2
Note, sol’n for equivalent structure sideways and ***F***=*W*
(also note change of lettering c/w original sol)

2c)



For reactions consider FBD of complete structure:





$\sin\theta = \frac{1}{\sqrt{5}}$, $\cos\theta = \frac{2}{\sqrt{5}}$

For static equilibrium:

$$\sum_E \circlearrowright = 0: \; R_{AH} \times \frac{3l}{8} + Wl = 0 \quad \Rightarrow \quad \underline{\underline{R_{AH} = -\frac{8}{3}W}}$$

ie opposite sense to that drawn

$$\sum_C \circlearrowright = 0: \; -R_{AH} \times \frac{l}{8} - R_{AV} \times \frac{l}{2} - W\frac{l}{2} = 0$$

$$\frac{8}{3}\frac{W\cancel{l}}{\cancel{8}} - R_{AV}\frac{\cancel{l}}{2} - W\frac{\cancel{l}}{2} = 0$$

$$\frac{R_{AV}}{2} = \frac{W}{3} - \frac{W}{2}$$

$$R_{AV} = \cancel{2}\frac{(2-3)W}{\cancel{6}\,3}$$

$$\underline{\underline{R_{AV} = -\frac{W}{3}}}$$

ie opposite sense to that drawn

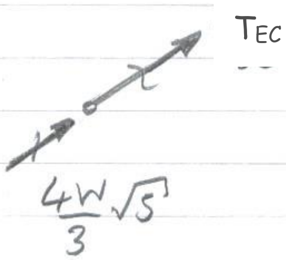
$\sum \uparrow^{+} = 0$: $R_{AV} + R_E \sin\theta - W = 0$

$$-\frac{W}{3} + R_E \frac{1}{\sqrt{5}} - W = 0$$

$$R_E = \frac{4W\sqrt{5}}{3}$$

For axial force in member DE
Consider joint @ D

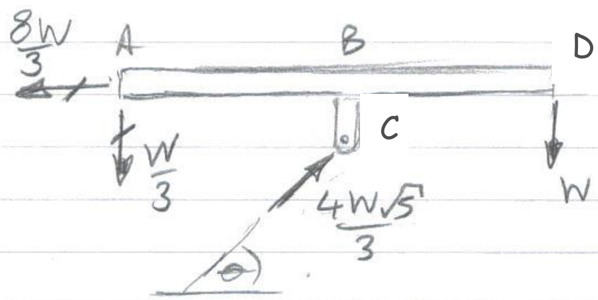
Axial force only in DE since pinned @ both ends and no transverse loads.



$\sum \nearrow^{+} = 0$: $\frac{4W\sqrt{5}}{3} + T_{EC} = 0 \Rightarrow T_{EC} = \frac{-4W\sqrt{5}}{3}$

ie compression.

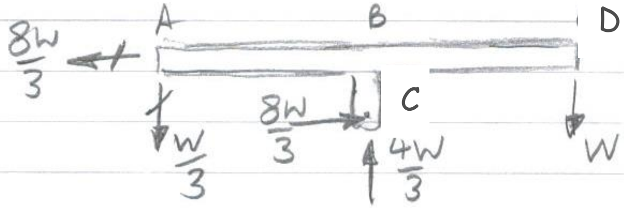
Next consider FBD of "beam" ABC :



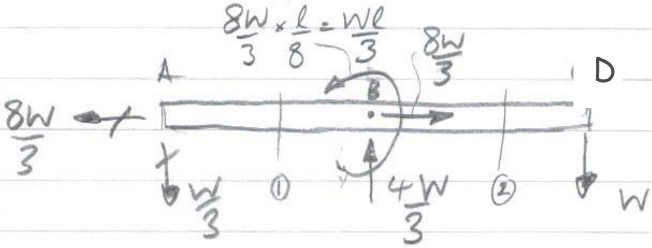
- More convenient to consider vertical + horiz'l components of force @ C :

$\uparrow$ Vertical: $\frac{4W\sqrt{5}}{3}\sin\theta = \frac{4W\sqrt{5}}{3} \times \frac{1}{\sqrt{5}} = \frac{4W}{3}$

$\rightarrow$ Horiz'l : $\frac{4W\sqrt{5}}{3}\cos\theta = \frac{4W\sqrt{5}}{3} \frac{2}{\sqrt{5}} = \frac{8W}{3}$

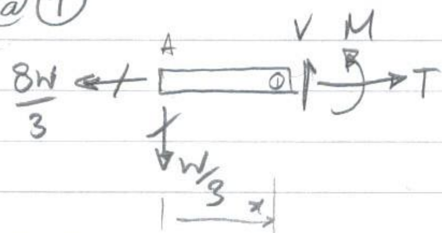


Note offset horiz'l force at E is equivalent to a horiz'l force + a moment at B. ie:



Consider FBDs @ sections ①, ② from LHS.:

@ ①

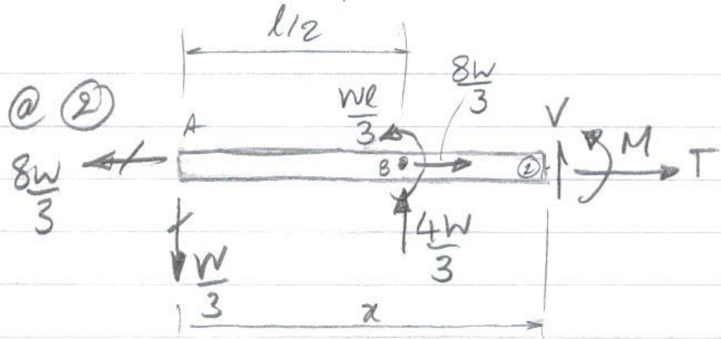


$\Sigma \overset{+}{\rightarrow} = 0: \quad -\frac{8W}{3} + T = 0 \quad \Rightarrow \quad \underline{T = \frac{8W}{3}}$ tension (1.1)

$\Sigma \overset{+}{\uparrow} = 0: \quad -\frac{W}{3} + V = 0 \quad \Rightarrow \quad \underline{V = \frac{W}{3}}$ (1.2)

$\Sigma ① = 0: \quad \frac{W}{3}x + M = 0 \quad \Rightarrow \quad \underline{M = -\frac{Wx}{3}}$ (1.3)

@ 2



$\sum \overset{+}{\rightarrow} = 0: \quad -\frac{8W}{3} + \frac{8W}{3} + T = 0 \quad \Rightarrow \quad \underline{\underline{T = 0}}$ (2.1)

$\sum \uparrow^{+} = 0 \quad -\frac{W}{3} + \frac{4W}{3} + V = 0 \quad \Rightarrow \quad \underline{\underline{V = -W}}$ (2.2)

$\sum \circlearrowleft (2) = 0 \quad \frac{W}{3}x - \frac{4W}{3}\left(x - \frac{l}{2}\right) + \frac{Wl}{3} + M = 0$

"point" or "concentrated" moment.

$\frac{Wx}{3} - \frac{4Wx}{3} + \frac{4Wl}{6} + \frac{Wl}{3} + M = 0$

$\hookrightarrow \underline{\underline{M = W(x - l)}}$ (2.3)

Check points

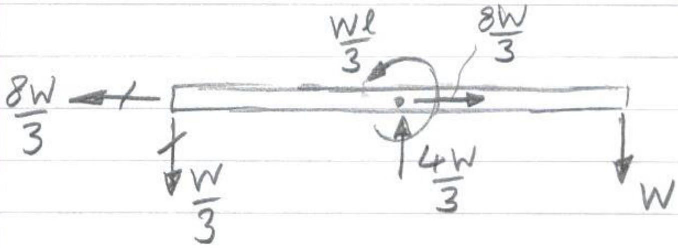
@ $x = 0$: (1.#) $\Rightarrow T = \frac{8W}{3}$, $V = \frac{W}{3}$, $M = 0$

@ $x = \frac{l}{2}^-$: " " , " , $M = -\frac{Wl}{6}$

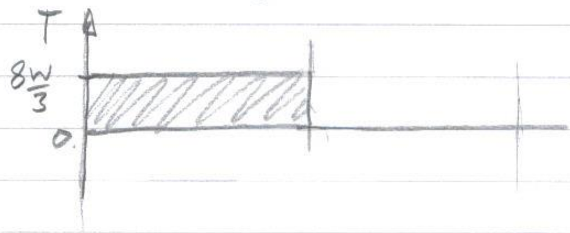
@ $x = \frac{l}{2}^+$: (2.#) $\Rightarrow T = 0$, $V = -W$, $M = -\frac{Wl}{2}$

@ $x = l$: " " , " , $M = 0$

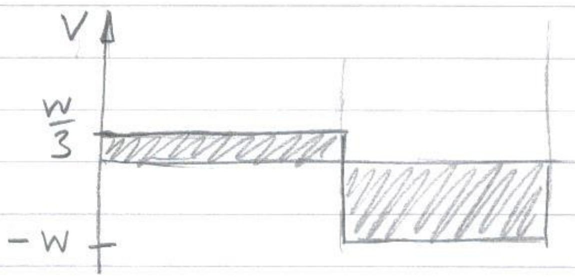
Beam AF, SF, BM diagrams.



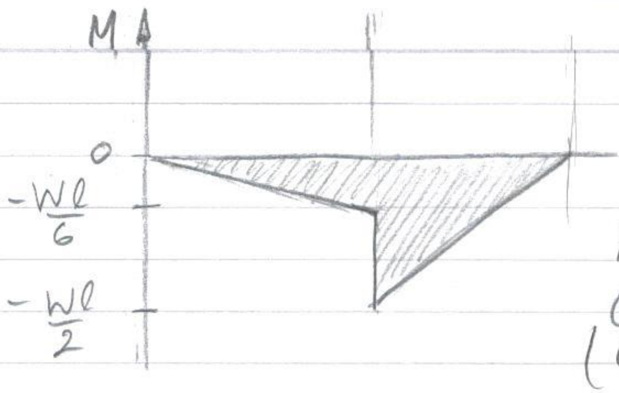
Axial force diagram:



Shear force diagram:



Bending moment diagram:



Note step change in M @ point moment application (c/w step change in V where a shear force is applied)

Q3

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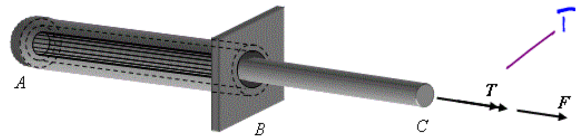
JRF
10.2.2014

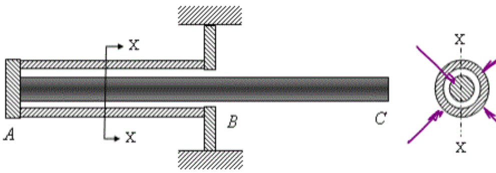
Q3



$T = 1000$ Nm
$F = 20$ kN

} separate load cases.

Figure Q3



TUBE:
OD = 70 mm
ID = 60 mm

BAR:
DIA = 40 mm

a) Torsion.

(i) Maximum shear stress in bar and tube.

Torsion equations: $\frac{\tau}{R} = \frac{T}{J} = \frac{G\theta}{L} \rightarrow \tau = \frac{TR}{J}$

Where $J = \pi D^4/32$

So, bar: $\tau = \frac{1000 \times 10^3 \times 40/2}{\pi\, 40^4/32} = \underline{\underline{79.6}}\ \text{N/mm}^2$

tube: $\tau = \frac{1000 \times 10^3 \times 70/2}{\pi\,(70^4 - 60^4)/32} = \underline{\underline{32.3}}\ \text{N/mm}^2$

(ii) Angle of twist at end c of bar relative to fixed plate @ B.

- Given by combined twist of bar and tube

From torsion equations: $\theta = \frac{TL}{GJ}$ rad.

bar: $\theta = \frac{1000 \times 10^3 \times 1000}{27'000 \times \pi \times 40^4/32} = 0.1474$ rad.

tube: $\theta = \frac{1000 \times 10^3 \times 500}{27'000 \times \pi \times (70^4 - 60^4)/32} = 0.0171$ rad

2π rad $= 360°$
1 rad $= \frac{360}{2\pi}$
$1° = \frac{180}{\pi}$

$\underline{\underline{\text{total}}}$
$= 0.165$ rad
$\downarrow$
$\underline{\underline{9.4°}}$

(iii) Assumptions: rigid end plate @ A, fixture @ B. Rigid welds.
Free torsion, ie neglect of axial stress due to constraints.

b) Axial loading.

(i) Direct stress $\sigma = F/A$

bar: $\sigma = \dfrac{20'000}{\pi \times 20^2} = \underline{\underline{15.9}}\ N/mm^2$

tube: $\sigma = \dfrac{20'000}{\pi(35^2 - 30^2)} = \underline{\underline{19.6}}\ N/mm^2$

(ii) Deflection at end C

- Given by combined extension of bar and tube

From Hooke's Law: $\varepsilon = \dfrac{\sigma}{E}$ and $\Delta L = \varepsilon . L \rightarrow \Delta L = \dfrac{\sigma}{E} . L$

$$\left.\begin{aligned} \text{bar: } \Delta L &= \frac{15.9}{70'000} \times 1000 = 0.23 \text{ mm} \\ \text{tube: } \Delta L &= \frac{19.6}{70'000} \times 500 = 0.14 \text{ mm} \end{aligned}\right\} \begin{aligned} &\text{total} \\ &= \underline{\underline{0.37}} \text{ mm} \end{aligned}$$

(iii) Assumptions: No deflection of end plate, fixed plate or welds.

Q4

Q4

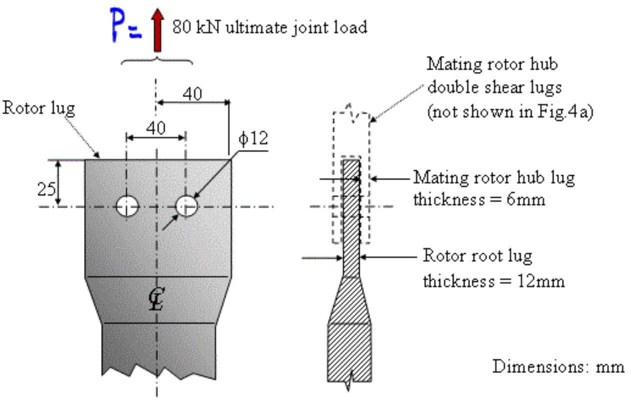


Figure Q4a **Figure Q4b**

Rotor lug checks:

tension: $\sigma = \dfrac{P}{(w-d)t} = \dfrac{40'000}{(40-12)\times 12} = 119 \ N/mm^2$: $\boxed{RF = \dfrac{440}{119} = 3.7}$

Shear-out $\tau = \dfrac{P}{2at} = \dfrac{40'000}{2\times 25\times 12} = 67 \ N/mm^2$: $\boxed{RF = \dfrac{255}{67} = 3.8}$

Bearing: $\sigma_{br} = \dfrac{P}{dt} = \dfrac{40'000}{12\times 12} = 278 \ N/mm^2$: $\boxed{RF = \dfrac{660}{278} = 2.4}$

Bolt checks:

Shear: $\tau = \dfrac{P}{2\pi\left(\frac{d}{2}\right)^2} = \dfrac{40'000}{2\pi\left(\frac{12}{2}\right)^2} = 177 \ N/mm^2$ $\boxed{RF = \dfrac{517}{177} = 2.9}$

Double shear joint.

Bolt bending: $\sigma = \dfrac{My}{I}$ where:

assuming no gap

$M = \dfrac{P}{2}\left(\dfrac{t_o}{2} + \dfrac{t_i}{4} + g\right) = \dfrac{40'000}{2}\left(\dfrac{6}{2} + \dfrac{12}{4} + 0\right) = 120\times 10^3 \ Nmm$

$y = \dfrac{d}{2} = \dfrac{12}{2} = 6 \ mm$

$I = \dfrac{\pi d^4}{64} = \dfrac{\pi \times 12^4}{64} = 1.018\times 10^3 \ mm^4$

$\sigma = \dfrac{120\times 10^3 \times 6}{1.018\times 10^3} = \underline{\underline{707 \ N/mm^2}}$

Note, this is a conservative estimate!

$\boxed{RF = \dfrac{1250}{707} = 1.8}$

The lowest RF is bolt bending but this is a conservative check, although it does emphasise the need for good tolerance of fit between the lugs.

The next lowest RF is for lug bearing, which is generally favoured for its more benign effect and joint loosening giving some warning of failure.

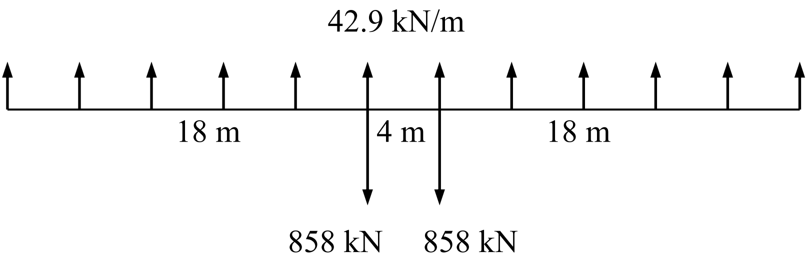
Q5

a) Aerodynamic load on wing = 100,000 x 9.81 x 2.5 = 2452 kN

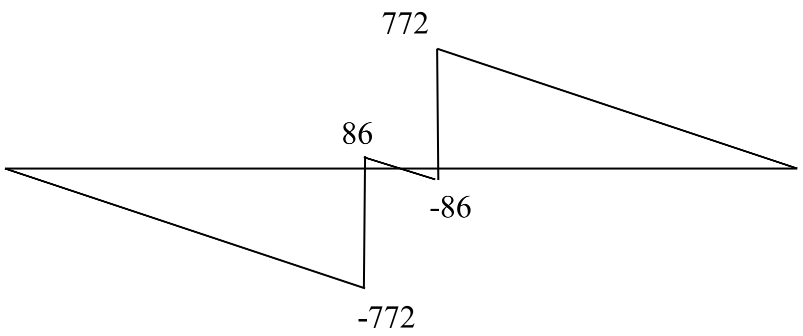
Wing fuel and structure inertia load = (10,000+20,000) x 9.81 x 2.5 = 736 kN

∴ net load from fuselage = 1716 kN, i.e. 858 kN each side

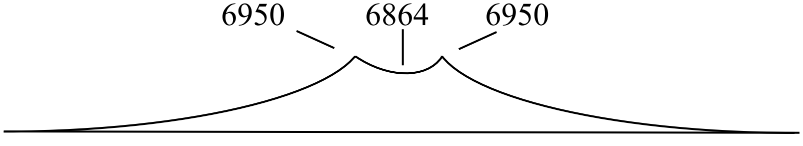
Net distributed wing loading = 1716/40 = 42.9 kN/m



Shear force diagram with principal values (kN):



Bending moment diagram with principal values (kNm)



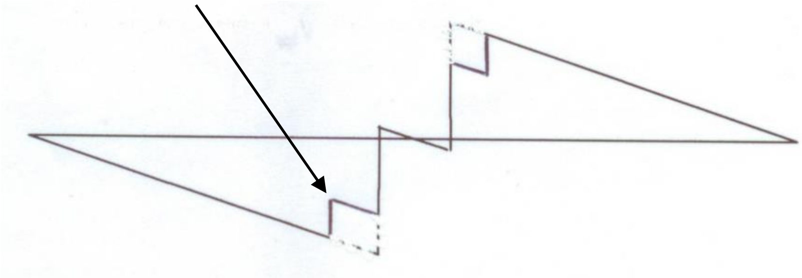
b) With the engines on the wing, the aerodynamic load on the wing is the same because the overall mass and load factor are unchanged.

There are downward loads on the wing due to the inertia loads from the engines.

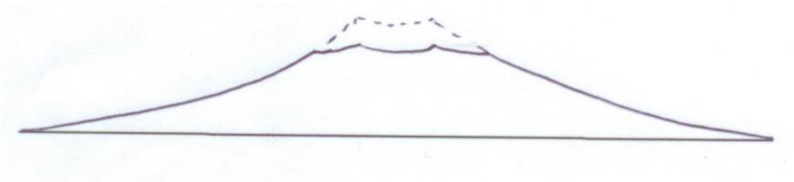
The fuselage reactions are reduced by the same amount.

The maximum shear force is therefore reduced:

Reduction in shear force due
to engine inertia loading



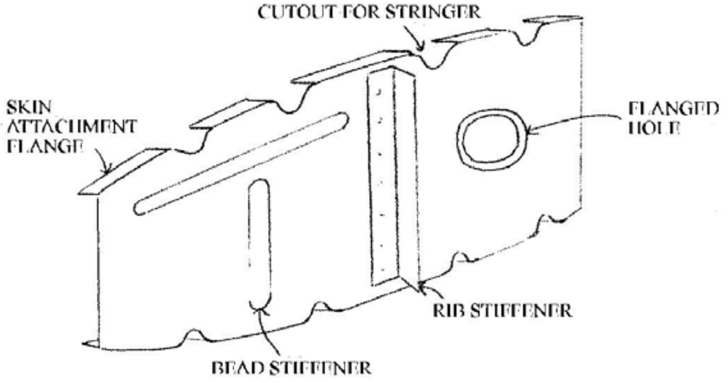
Similarly the maximum bending moment is reduced:



c) Functions of ribs:

- maintain wing cross-section
- transfer shear loading into spars
- redistribute discrete loads e.g. undercarriage, flaps
- support skin/stringers against compressive buckling
- divide skin into panels to reduce shear buckling
- carry Brazier loads due to curvature as wing bends

Labelled sketch showing rib stiffening, cutouts for stringers, attachment flanges



SECTION B

Q6.

a) What are the factors which determine the strength of composite materials? (3 marks)

The fibre volume fraction

Aspect ratio of fibres

Orientation of fibres

Strength of fibres and strength of matrix (4 marks)

b) Carbon fibres provide longitudinal fibre reinforcement to a nylon thermoplastic material subject to a tensile load. If the volume fraction (V_f) of carbon fibres = 60%, what is the modulus of elasticity of carbon/nylon composite along the direction of alignment of carbon fibres given moduli of carbon fibres and nylon as: E_{carbon} = 210 GPa and E_{nylon} = 2.8 GPa. (5 marks)

Rule of Mixture

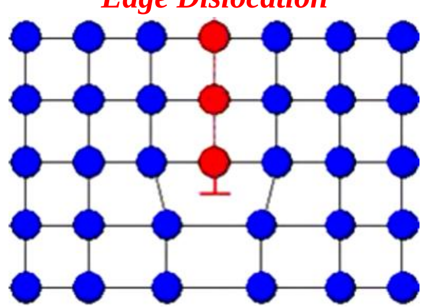
$E_c = E_f V_f + E_m (1-V_f)$ ***(2 marks)***

$E_c = (210 \times 10^9 \times 0.6) + (2.8 \times 10^9 \times 0.4) = 127.12 \times 10^9$ ***Pa or 127.12GPa***

(3 marks)

c) With help of schematic diagram explain what edge dislocation is. What happens to dislocations at the yield point of metal? (4 marks)

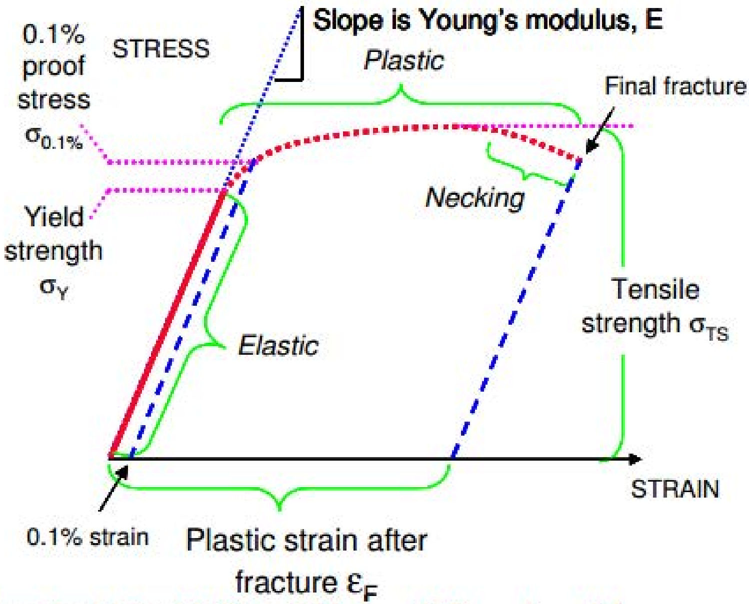
Edge Dislocation



(2 points)

Edge dislocation is a line defect present in crystal lattice with one additional half plane of atoms inserted which distorts the neighbouring atoms in the crystal structure. *(2 points)*

d) Draw a schematic representation of the stress-strain curve you would expect to obtain from a tensile test ona metal specimen at room temperature. Identify and define key mechanical properties you could determine from that data. (6 marks)



[3 marks for drawing, 1 mark each for labelling *yield strength*, *Young's modulus* and *Tensile strength*]

Q7

a) Compare the advantages and disadvantages of thermoset over thermoplastic polymers. Give example of one thermoplastic and thermoset polymer. (5 Marks)

Thermoplastics:

Advantages: Recyclable; easy to mould into a final shape by heating
Disadvantages: Low strength and stiffness, cannot be used at high temperatures
Example: Nylon

Thermosets:

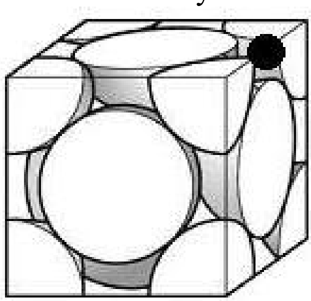
Advantages: High stiffness and strength, relatively stable at high temperatures
Disadvantages: non-recyclable, not easy to shape/mould into a final product
(5 marks)

Example: Epoxy

(5 marks)

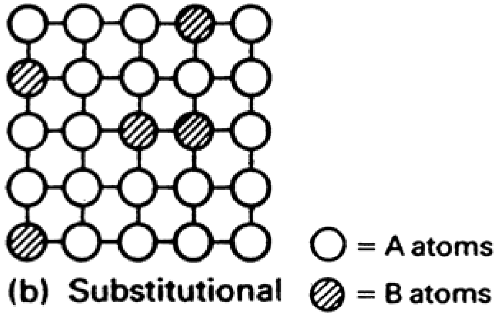
b) What is the difference between interstitial and substitutional alloy? Explain how alloying can increase the strength of metals. (6 marks)

Interstitial Alloy:



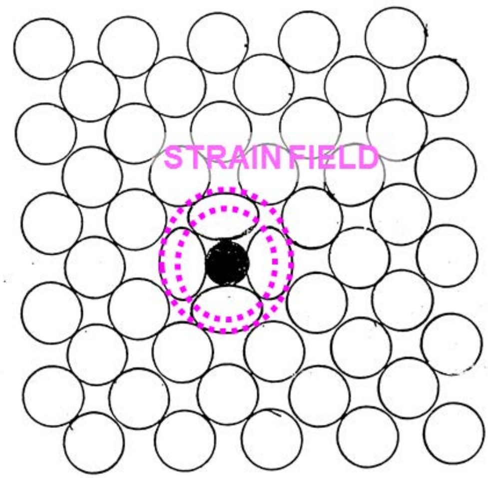
In interstitial alloying small atom such as carbon can fit into the gap present in the crystal lattice of metals as shown in figure above. Only small fraction of alloying atoms can be added in interstitial apply due to limited space available in crystal lattice. (2 marks)

The substitutional alloy the solute atoms substituted for parent solvent atoms in lattice as shown in figure below. Unlike the interstitial alloy any composition ranging from 0-100% can be achieved in substitutional alloy.



(2 marks)

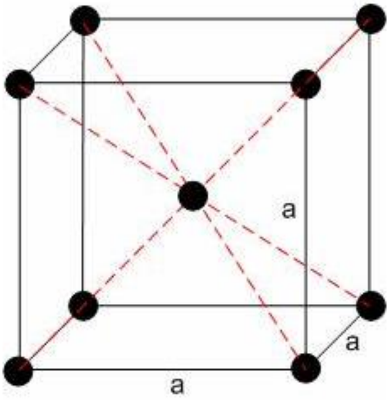
The presence of dissimilar atom due to alloying creates a localised strain field as shown in figure below. During deformation of metal alloy under mechanical loading the dislocation movement is restricted due to presence of the localised strain region which increases the strength of the alloy as compared to neat metal.



(2 marks)

c) Explain the basic crystal structure of face centred cubic crystal (FCC) and body centre cubic (BCC) crystal lattice. How many atoms are present inside the unit lattice of FCC and BCC crystal lattice? (6 marks)

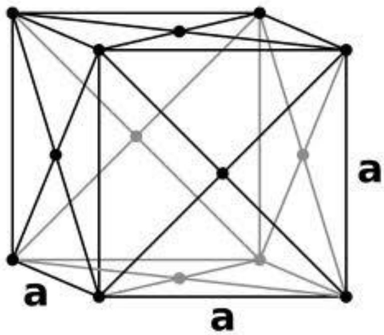
Body centred cubic (BCC) structure has 8 atoms present at the corner of the cube and one atom at the centre of the cube as shown in figure below. The number of atoms present inside the lattice of BCC is 2.



BCC

(3 marks)

face centred cubic (FCC) structure has 8 atoms present at the corner of the cube and one atom each at the centre of face of the cube as shown in figure below. The number of atoms present inside the lattice of FCC is 4.



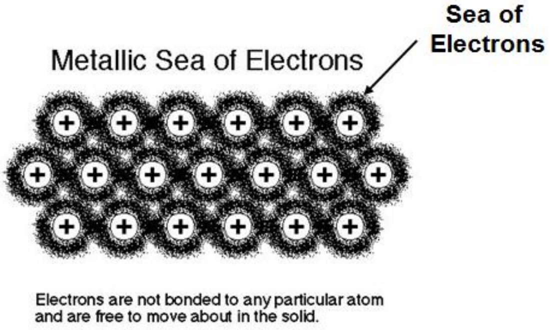
(3 marks)

e) What are different type of chemical bonds and briefly explain nature of each type of bond. (5 marks)

COVALENT: Electrons shared with adjacent atoms e g carbon carbon bond C-C

Ionic Bond: Complete transfer (not sharing) of electron from one atom to another atom. Give rise to positive and negative ion due to electron transfer. Attraction between opposite charged ions
Non-directional e.g. Na+ Cl- = NaCl

METALLIC BOND: Metal atoms can easily donate electrons
This results in sea of mobile electrons which are free to move around. The mobile electrons are shared by number of metal ions as shown in figure below



The bonding between number of metal ions with the mobile electron sea results in Metallic Bond.