CONFIDENTIAL

Universiti Tun Hussein Onn Malaysia

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER II
## SESSION 2013/2014

| | | |
|---|---|---|
| COURSE NAME | : | SOLID MECHANICS |
| COURSE CODE | : | BDU 20802 |
| PROGRAMME | : | 2 BDM |
| EXAMINATION DATE | : | JUNE 2014 |
| DURATION | : | 2 HOURS 30 MINUTES |
| INSTRUCTION | : | ANSWER **FOUR (4)** OUT OF **FIVE (5)** QUESTIONS |

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

**Q1** A hollow cylinder with a diameter of 0.5 m is subject to uniformly distributed axial load of 10 kN/m as shown in the **Figure Q1**.
(E=90 Gpa)

(a) State the equation to solve deformation under axial loading problem (including thermal stress).

(2 marks)

(b) If the thickness, t is 10 mm, determine the deformation, $\delta$ of the cylinder when 10 kN/m distribution load applied at position of t/2

(5 marks)

(c) Given 0.15 mm of the deformation, $\delta$ determine:

i. The inner radius and radius at position t/2 in function of t.

(3 marks)

ii. The load in function of t.

(3 marks)

iii. The thickness.

(12 marks)

**Q2** Airbus A380 has a total of 4 engines with 100 kg each located at port and starboard wing as illustrated in **Figure Q2**. The width of the center fuselage is 6.58 m and the length from wing root to wing tip 43.5 m. This aircraft loaded with 50 kg of GTL fuel distributed evenly in each wing at section A. Assume the wing is in horizontal condition when there is no fuel loaded and engines mounted on the aircraft. When the external loads are applied (fuel and engines):
($g$=9. 81 m/s$^2$)

(a) Draw the free body diagram (cantilever beam) for one wing only

(5 marks)

(b) Produce a shear and moment diagram.

(15 marks)

(c) If all engines are removed and no fuel inside the wing, determine the wing tip deflection if 150 kg load applied at 28 m from wing root. Refer**Table 1** to calculate the deflection.
(E=140 MPa, I=64.5m$^4$; assume the cross-section area is uniform along the wing)

(5 marks)

**Q3** Center of fuselage A380 is built with a number of stringers made from aluminum 7075 as shown in **Figure Q3(a)**. The cross section area of the stringer is 'T' shape as in **Figure Q3(b)**. In flight level, the captain gives a positive input deflection on elevator to climb from 20000 m to 30000 m. This action induces moment downward direction with magnitude of 30 kNm on stringer-A. By analyzing Stringer-A which located at uppermost, determine

(E = 760MPa)

(a) Determine the centroid point

(8marks)

(b) Determine moment of inertia

(7marks)

(c) Use the flexural formula to find the maximum tensile and compressive stresses

(7marks)

(d) If the stringer has deflection, determine the radius of curvature and illustrate the center of the curvature

(3 marks)

**Q4** (a) Shaft *BC* is hollow with inner and outer diameters of 85 mm and 125 mm, respectively. Shafts *AB* and *CD* are solid with diameter *d*. For the loading shown in **Figure Q4(a)**, determine:

i. The place of maximum and minimum stress happen in shaft BC

(2 marks)

ii. The minimum and maximum shear stress in shaft *BC*

(6 marks)

iii. The required diameter *d* of shafts *AB* and *CD* if the allowable shearing stress in these shafts is 65 MPa

(4 marks)

iv. The outer diameter, $d_o$ of shafts *BC* if the allowable shearing stress in this shaft is 40 MPa. (Given inner diameter, $d_i$ of shaft BC is 50 mm)

(5 marks)

(b) To design a transmission shaft, designer must able to determine cross-section of the shaft in order the transmission shaft will work without fail.

i. Explain what is the relationship between shaft cross-section area and the shaft failure

(2 marks)

ii. A solid steel shaft AB shown in **Figure Q4(b)** is to be used to transmit 3750 W from the motor M to which it is attached. If the shaft rotates at $\omega$ = 175 RPM and the steel has the allowable shear stress of $\tau_{allow}$ =100 Mpa, determine the torque transmitted to the shaft and the diameter of shaft. Next find the frequency of rotation of the shaft

(6 marks)

**Q5** (a) A thin cylinder with 75 mm outer diameter, 249 mm long with walls 2.5 mm thick is subjected to an internal pressure of 7 MN/m$^2$. (E = 200 GPa, $v$ = 0.3 ). Determine;

i. The change in internal diameter,

(8 marks)

ii. The change in length,

(8 marks)

iii. Hoop stress and longitudinal stress.

(9 marks)

**- END OF QUESTION -**

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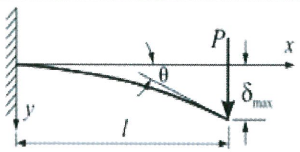
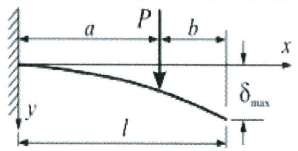
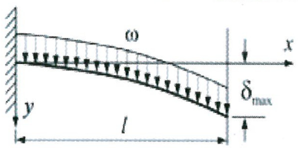
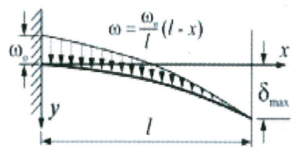
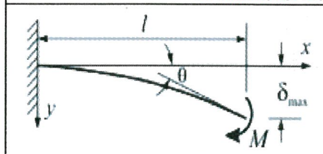
| BEAM TYPE | SLOPE AT FREE END | DEFLECTION AT ANY SECTION IN TERMS OF $x$ | MAXIMUM DEFLECTION |
|---|---|---|---|
| 1. Cantilever Beam – Concentrated load $P$ at the free end | | | |
|  | $\theta = \frac{Pl^2}{2EI}$ | $y = \frac{Px^2}{6EI}(3l - x)$ | $\delta_{max} = \frac{Pl^3}{3EI}$ |
| 2. Cantilever Beam – Concentrated load $P$ at any point | | | |
|  | $\theta = \frac{Pa^2}{2EI}$ | $y = \frac{Px^2}{6EI}(3a - x)$ for $0 < x < a$<br>$y = \frac{Pa^2}{6EI}(3x - a)$ for $a < x < l$ | $\delta_{max} = \frac{Pa^2}{6EI}(3l - a)$ |
| 3. Cantilever Beam – Uniformly distributed load ω (N/m) | | | |
|  | $\theta = \frac{\omega l^3}{6EI}$ | $y = \frac{\omega x^2}{24EI}(x^2 + 6l^2 - 4lx)$ | $\delta_{max} = \frac{\omega l^4}{8EI}$ |
| 4. Cantilever Beam – Uniformly varying load: Maximum intensity $\omega_o$ (N/m) | | | |
|  | $\theta = \frac{\omega_o l^3}{24EI}$ | $y = \frac{\omega_o x^2}{120lEI}(10l^3 - 10l^2 x + 5lx^2 - x^3)$ | $\delta_{max} = \frac{\omega_o l^4}{30EI}$ |
| 5. Cantilever Beam – Couple moment $M$ at the free end | | | |
|  | $\theta = \frac{Ml}{EI}$ | $y = \frac{Mx^2}{2EI}$ | $\delta_{max} = \frac{Ml^2}{2EI}$ |

**Table 1** :Deflection of Beam

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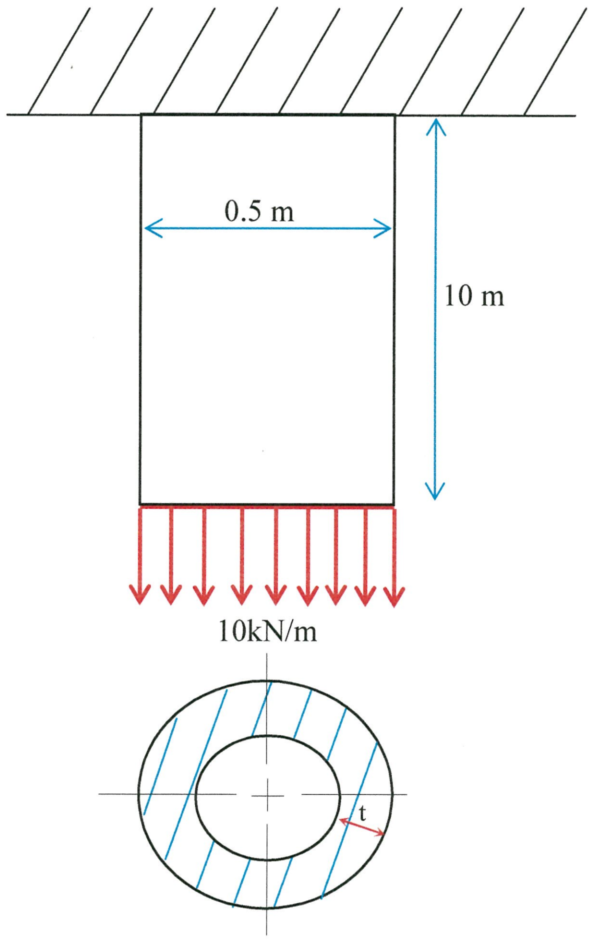


**FIGURE Q1**

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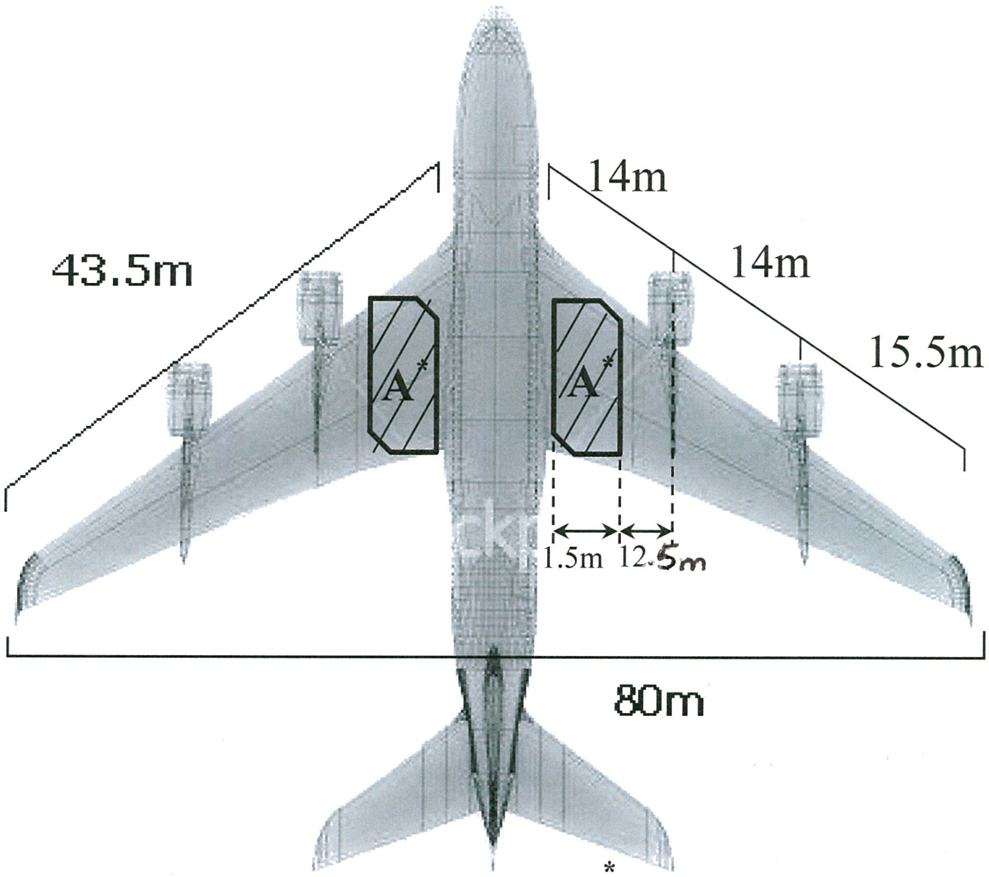


**FIGURE Q2**

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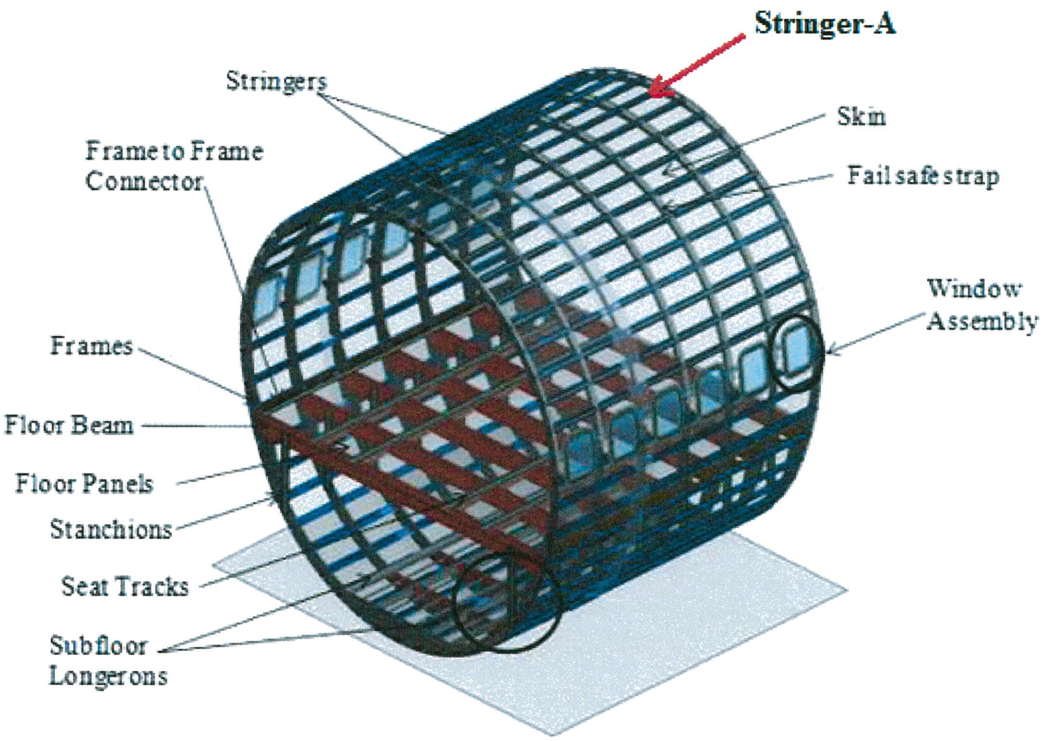


**FIGURE Q3(a)**

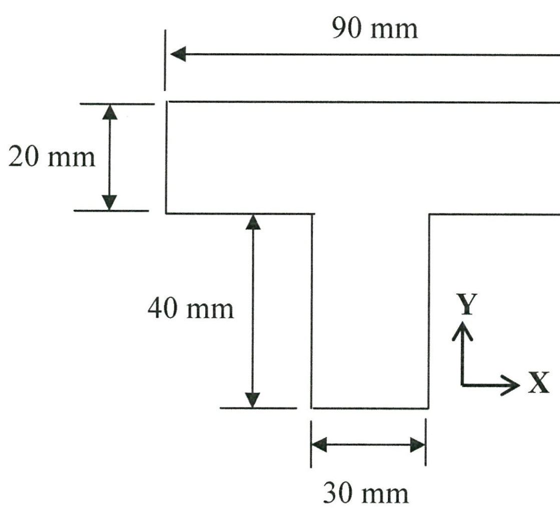


**FIGURE Q3(b)**

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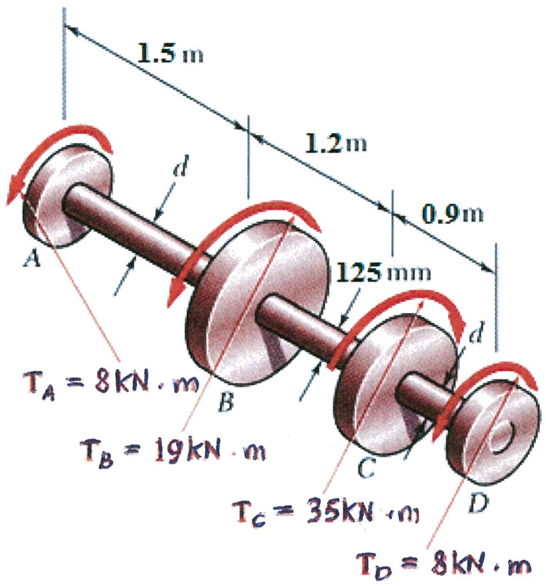


**FIGURE Q4(a)**

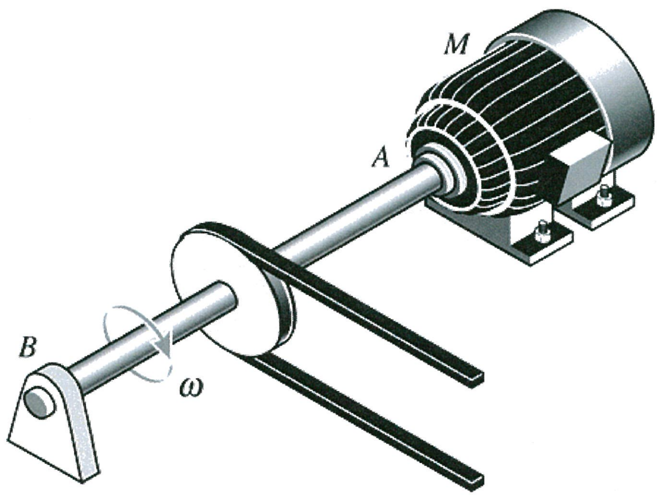


**FIGURE Q4(b)**