Examination Period 3: 2016/17

ENG205317N

Module Title Solid Mechanics
Level Five
Time Allowed Two hours

Instructions to students:

- Enter your student number not your name on all answer books.
- Answer four out of five questions.
- All questions are equally weighted.
- Begin each question in a separate answer book; label each answer book clearly with the number of the question you are answering.
- Students are permitted to take one sheet of A4 paper (one side of notes) into the examination room. Notes can be hand written or typed (not less than 12pt). All notes should be attached to the answer book at the end of the examination.
- The use of a non-programmable calculator is permitted.
- Mathematical formulae booklet will be provided.

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Answer four out of five questions.

Question 1

Two steel bars are used to reinforce a brass bar with width of 40mm that is subjected to load \(P=25\, \text{kN}\). When the steel bars were fabricated, the distance between the centres of the holes that were to fit on the pins was made 0.5 mm smaller than the 2m needed, see Figure 1. The steel bars were then placed in an oven to increase their length so that they would just fit on the pins. Following fabrication, the temperature in the steel bars dropped back to room temperature. Determine:

a. the increase in temperature that was required to fit the steel bars on the pins.

b. the stress in the brass bar due to the fabrication process.

c. the stress in the brass bar after the load is applied to it.

Total: 25 marks

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**Figure 1**

Steel \((E_s = 200\, \text{GPa} \text{ and } \alpha_s = 11.7 \times 10^{-6}/\text{°C})\)

Brass \((E_b = 105\, \text{GPa} \text{ and } \alpha_b = 20.9 \times 10^{-6}/\text{°C})\)
Question 2

For the gear train shown, the diameters of the three solid shafts are:

\[ d_{AB} = 20\text{mm} \quad d_{CD} = 25\text{mm} \quad d_{EF} = 40\text{mm} \]

Knowing that for each shaft the allowable shearing stress is 60 MPa, determine the largest torque \( T \) that can be applied, see Figure 2. The pitch circle radii of gears B, C, D and E are shown in Figure 2.

Total: 25 marks
Question 3

Determine the maximum normal stress due to bending and draw the shear and bending-moment diagrams for the beam and loading shown in Figure 3. For W410×114 rolled steel section modulus is $2200 \times 10^3$ mm$^3$.

Total: 25 marks
Question 4

In a lift installation a section of the guide rail system between each pair of brackets in the first approximation can be treated as a simply supported beam. In the lift car position shown in Figure 4 the guide rail section AB of length l is subjected to bending due to force resulting from the eccentricity e of load mass Q. If the flexural rigidity of the rail is EI, the vertical distance between the centrelines of car shoes is h determine:

a. the bending force F due to the eccentricity of the car load.

b. the equation of the elastic curve for the rail section AB.

Figure 4

Total: 25 marks
Question 5

Figure 5 shows a machine component ABD with three perpendicular forces applied on it from x, y and z directions. It is known that the cross section containing point Q is a 20mm × 40mm rectangle. Determine the principal stresses and the maximum shearing stresses acting at point Q.

Total: 25 marks