UNIVERSITY OF SOUTH AUSTRALIA
SCHOOL OF NATURAL AND BUILT ENVIRONMENTS

FIRST SEMESTER EXAMINATIONS

JUNE 2005

MECHANICS AND STRUCTURES

GENERAL INSTRUCTIONS TO CANDIDATES:

Lecturer: **Dr Y Zhuge**
Course: **Year: 2nd year**
Reading Time: 10 mins
Exam Duration: **3 hours**

1. Attempt ALL questions.
2. Marks for questions are shown in brackets.
3. A formula sheet is provided.
4. This is a **close book** examination.

QUESTION 1

The beam is supported by the three pin-connected suspender bars, each having a diameter of 50 mm and made of steel with E_{steel} = 200 GPa (Figure 1). Determine the greatest uniform load **w** that can be applied to the beam without causing AB and CB to buckle or yield. Assume steel yield stress = 250 MPa.

[15 marks]

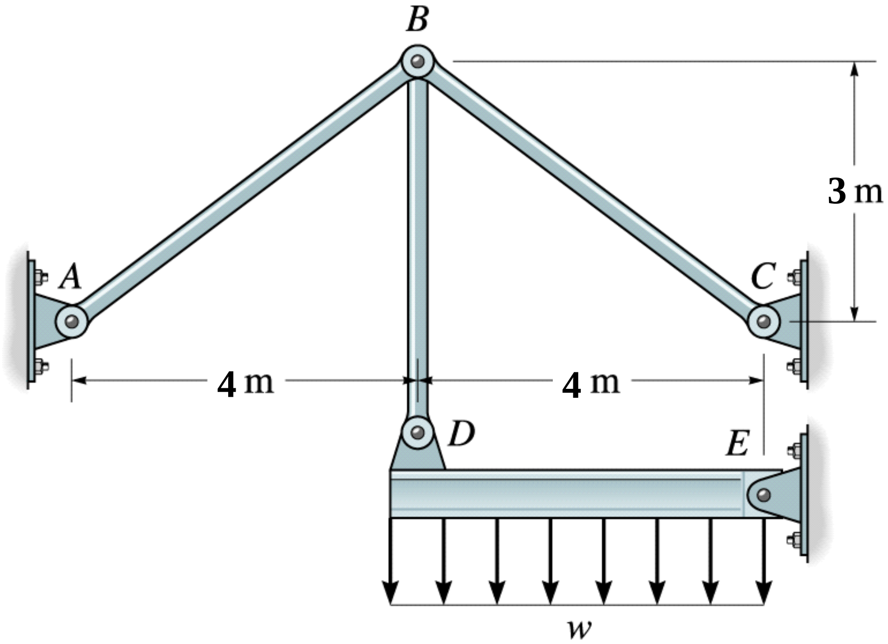


FIGURE 1

Contd/…

QUESTION 2

The turbine develops 150 kW of power, which is transmitted to the gears such that C receives 70% and D receives 30%. If the rotation of the 100 mm diameter A-36 steel shaft is ω = 85 rad/s, determine the absolute maximum shear stress in the shaft and the angle of twist of end E of the shaft relative to B. The journal bearing at E allows the shaft to turn freely about its axis. G = 75 GPa.

[16 marks]

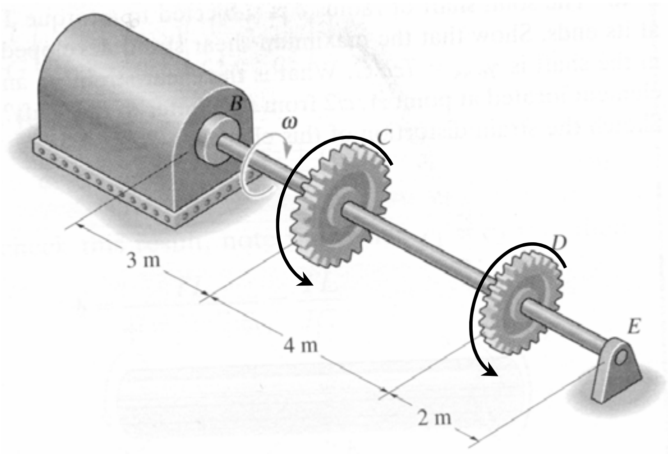


FIGURE 2

QUESTION 3

The bar is pinned at A and supported by two aluminium rods, each having a diameter of 25 mm and a modulus of elasticity E_{al} = 70 GPa. If the bar is assumed to be rigid and initially vertical, determine the force in each rod and the displacement of the end B when the force of 10 kN is applied. (**Hint: treat as a statically indeterminate problem**)

[16 marks]

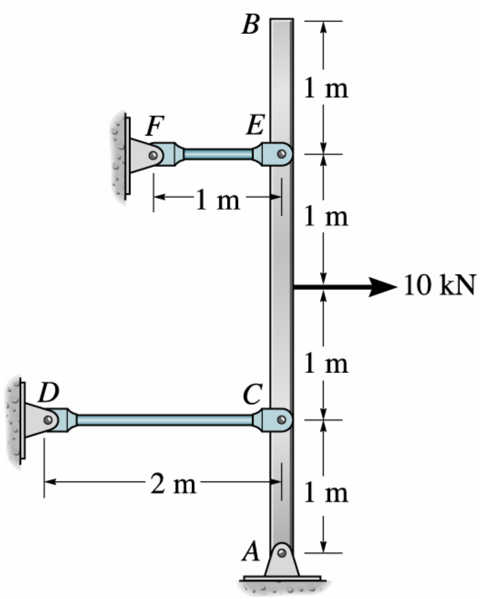


FIGURE 3

Contd/…

QUESTION 4

A torque wrench is used to tighten the nut on a bolt. If the dial indicates that a torque of 80 Nm is applied when the bolt is fully tightened, determine the force **P** acting at the handle and the distance "**s**" the needle moves along the scale. Assume only the portion AB of the beam distorts. The cross section is square having dimensions of 13 mm by 13 mm. E = 200 GPa. (**Hint: assume point A has a fixed support and treat the wrench as a cantilever beam, then determine the equation of the elastic curve first)**

[18 marks]

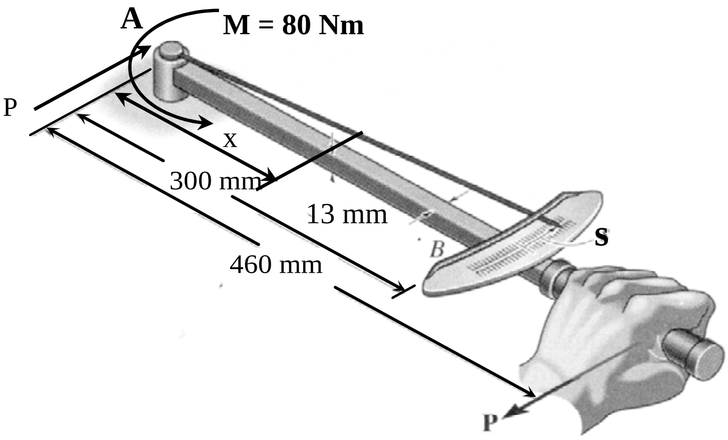


FIGURE 4

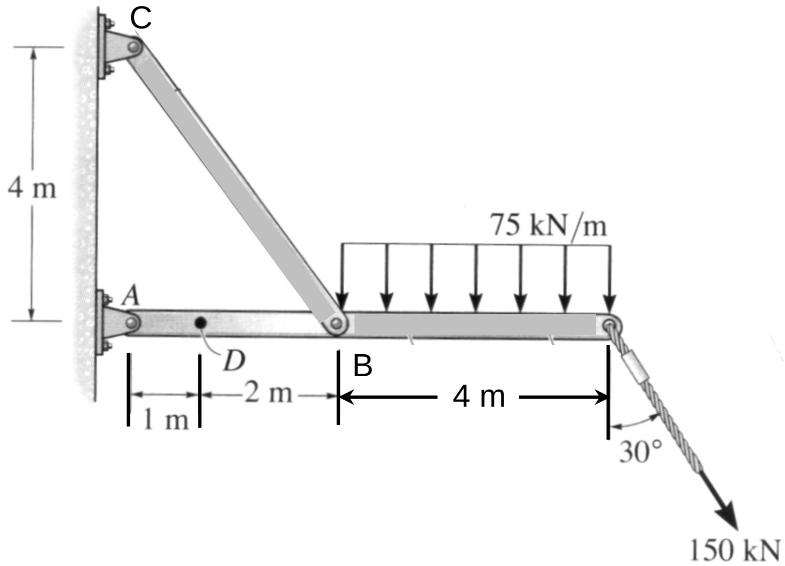
QUESTION 5

The frame supports the loading shown in Figure 5.

(a) Determine the state of stress at point D, which is located just on the web, and represent the results on a differential volume element located at this point.

(b) Determine the principal stresses acting at point D (on the web) and specify the orientation of the element.

[35 marks]



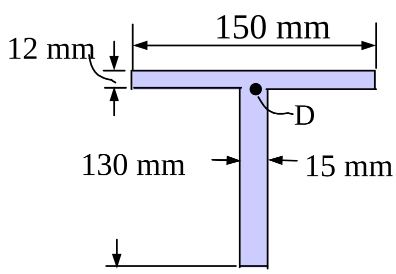


FIGURE 5

<u>END OF PAPER</u>

Formula Sheet

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i A_i}{\sum_{i=1}^{n} A_i}, \quad \bar{y} = \frac{\sum_{i=1}^{n} y_i A_i}{\sum_{i=1}^{n} A_i}$$

$$I_x = I'_{xc} + A d_y^2$$
$$I_y = I'_{yc} + A d_x^2$$

$$\sigma = \frac{P}{A}, \ \tau = \frac{V}{A}, \ \delta = \sum \frac{PL}{AE}$$

$$\tau = \frac{T\rho}{J}, \quad J = I_x + I_y$$
$$P = T\omega, \quad \phi = \sum \frac{TL}{JG}$$

$$\sigma_x = \frac{My}{I}, \quad \tau = \frac{VQ}{Ib}, \ Q = A'\bar{y}'$$

$$\sigma'_x = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta,$$
$$\tan 2\theta_p = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$EI\frac{d^2v}{dx^2} = EIv'' = -M(x)$$

$P_{cr} = \dfrac{\pi^2 EI}{(KL)^2}$ (K=1, pinned ends; K=2, fixed and free ends; K=0.5, fixed ends; K=0.7, pinned and fixed ends)