

**MM2MS2 Mechanics of Solids 2**  
**Exercise Sheet 5 - Elastic-Plastic Deformations**

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For all questions assume  $E = 200\text{GPa}$ ;  $G = 75\text{GPa}$ ;  $\sigma_y = 250\text{MPa}$  for steel.

1. A steel beam of rectangular section 10mm x 30mm is subjected to pure bending in a plane parallel to the 30mm faces. Ideal elastic-plastic behaviour may be assumed. Calculate the bending moment,  $M$ , necessary for:
  - (a) the onset of yield,
  - (b) complete yield through the section.

**[Ans: a) 375Nm, b) 562.5Nm]**

2. A bending moment of 400Nm is applied to the beam of question 1. (a) Calculate the surface strain. (b) Determine the maximum residual stress when the bending moment is removed.

**[Ans: a) 0.134 %, b)  $\pm 16.7\text{MPa}$ ]**

3. The web and flanges of a straight I-section steel beam are 80 mm wide and 10 mm thick. The beam is loaded in pure bending in the plane of the web until the whole of each flange has yielded but the whole of the web remains elastic. Calculate the residual curvature in the unloaded beam. Assume ideal elastic-plastic behaviour.

**[Ans:  $3.175 \times 10^{-3}\text{ m}^{-1}$ ]**

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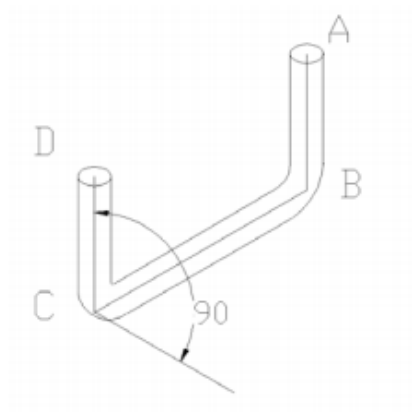
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4. A 10mm diameter steel rod, formed to the U-shape ABCD, as shown in Fig Q4, is stress free. The leg AB is restrained to remain vertical whilst the leg CD rotates through  $90^\circ$ . This twists BC, which has an effective length,  $l$ . When CD is released, calculate:

- (a) the minimum value of  $l$  at which CD returns to its original position (angular spring-back of  $90^\circ$ ),
- (b) the angular spring-back of CD if  $l = 200\text{mm}$ .

Assume ideal elastic-plastic material behaviour.



**Fig Q4**

**[Ans: a) Tresca:  $L = 4.703\text{m}$ , von Mises:  $L = 4.091\text{m}$ ; b) Tresca:  $5.093^\circ$ , von Mises:  $5.878^\circ$ ]**