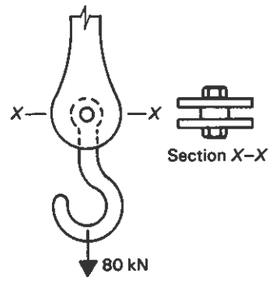
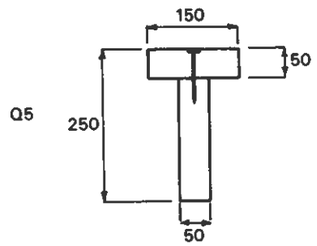
4. A crane hook is connected to a shackle by a single bolt as shown in figure Q4. If the hook is to carry a load of 80 kN and the safe shearing stress in the bolt is 80 N/mm^2, determine the minimum diameter of bolt required. (*Hint*: the bolt is in double shear.)
Ans. (25.23 mm)



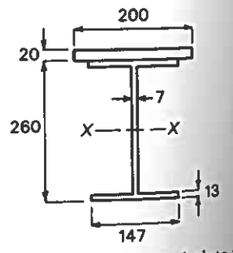
Q4

5. A T shaped beam is fabricated from two sections of timber nailed together as shown in figure Q5. If the section is subjected to a shearing force of 5 kN, calculate the shear stress at the level of the neutral axis and at the level just below the junction of the two pieces of timber. (*Hint*: first calculate the position of the centroid of the section.)
Ans. (0.58, 0.53 N/mm^2)

6. If each nail in the beam in figure Q5 can carry a shear force of 0.95 kN, what is the maximum spacing of the nails along the length of the beam? (*Hint*: you may have to think a little harder about this problem! In Q5 you calculated the shear stress at the level of the junction of the two pieces of timber. This will also be the complementary shear stress along the horizontal interface between the two timbers. What will be the shear *force* along, say, one metre length of the beam? If this shear force is resisted solely by the shearing action of the nails, how many nails are then required?)
Ans. (36.13 mm)



Q5



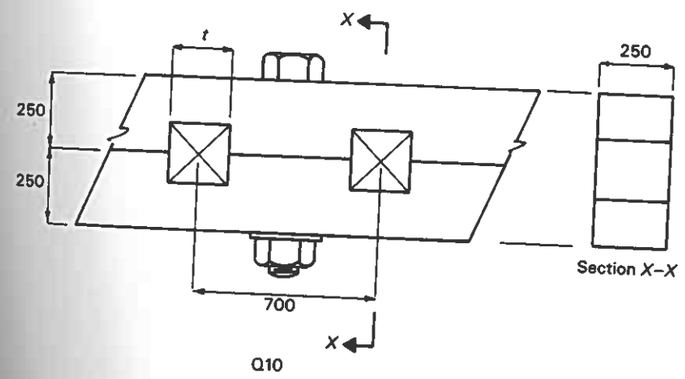
Q7

7. A Universal beam is strengthened by welding a 200 mm × 20 mm steel plate to the top flange as shown in figure Q7. If the allowable maximum shear stress is 70 N/mm^2, calculate the maximum shearing force that this section can sustain.
Ans. (119.02 kN)

8. A cantilevered beam carries a point load of '*W*' at its free end. If the beam has a circular cross-section of diameter *D*, what are the average and maximum shear stresses developed in the section? (*Hint*: to work out the first moment of area term in the general shear stress expression, you will have to employ numerical integration methods. You will also have to recall the expression for the second moment of area of a circle about a diameter.)
Ans. (1.27W/D^2, 1.70W/D^2)

9. If the beam in Q8 is replaced by a hexagonal cross-section of side length *s* and is orientated with one diagonal horizontal, what would now be the maximum shear stress in the section?
Ans. (0.462W/s^2)

10. A timber beam is simply supported at both ends and carries a central point load of 50 kN. The beam is fabricated from two 250 mm × 250 mm timbers which are bolted together as shown in figure Q10. The timbers are also keyed together by wooden keys which are spaced 700 mm apart. The maximum allowable average shear stress in the keys is 2 N/mm^2 and it is assumed that the keys resist all the longitudinal shear stress between the main timbers. Calculate the least required thickness of the keys, shown as dimension *t* on the drawing. (*Hint*: this problem is similar to Q5 and Q6. Do not attempt this question until you have done these two previous questions.)
Ans. (105.0 mm)



Q10