UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 2 Examination in Engineering: November 2016

Module Number: CE2302 **Module Name: Mechanics of Materials**

[Three Hours]

[Answer **all questions**, each question carries 12 marks]

All notations have their usual meanings

Q1. A girder beam used to support a bridge deck is 10 m long and simply supported over a span of 6 m. Schematic view of an idealized girder beam is shown in Fig. Q1(a). The piers of the bridge are positioned in such way that the girder beam is overhang at both ends and carries a uniformly distributed load (udl) of w kN/m over the entire length. The proposed cross section to be used for the above girder beam is a composite section as shown in Fig. Q1(b).

a) Plot the bending moment diagram for the above girder beam and hence determine;

i) The absolute maximum bending moment.

ii) Locations of points of contraflexure.

[6.0 Marks]

b) What is the maximum possible value for 'w' for the composite girder beam, if the ratio of young modulus between steel and timber is 16 and the maximum flexural strength of steel and timber are 150 N/mm^2 and 8 N/mm^2, respectively?

[6.0 Marks]

Q2. A simply supported beam ABCD subjected to two point loads, (i.e. 10 kN and 30 kN), is shown in Fig. Q2 (a). It is a built-up wooden box beam fabricated from two wooden boards, each 20 × 160 mm, serve as flanges and two plywood boards, each 20 mm thick and 300 mm height serve as webs. The flanges and webs are connected by wood adhesives having 5 N/mm^2 shear strength. The cross section shape and the element sizes of the box beam are shown in Fig. Q2 (b).

a) In terms of shear, what is the most critical segment of the beam?

[2.0 Marks]

b) With usual notations and neat sketches, show the critical shear stress component at a glue joint between a web and a flange.

[2.0 Marks]

c) Check whether the build-up box beam is safe against joint shear failure.

[4.0 Marks]

d) Estimate the minimum required shear strength of the wood adhesives for the beam segment BC.

[4.0 marks]

Q3. The in-plane normal and shear stresses acting on two mutually perpendicular planes of a small element in a structural body are shown in Fig. Q3 (a).

a) Draw Mohr's circle to represent the normal and the shear stresses at any plane of the element at the given stress point.

[2.0 Marks]

b) Using the Mohr's circle drawn in Part (a), determine the stress components σ_{aa}, σ_{bb} and τ_{ab} on the rotated element shown in Fig. Q3 (b) and mark them accurately based on the sign convention for Mohr's circle.

[4.0 Marks]

c) Determine principal stresses at the point and mark them on a stress block showing the angle of rotation accurately.

[4.0 Marks]

d) What is the maximum in-plane shear stress at the point?

[2.0 Marks]

Q4. a) State two theorems associated with Moment Area method of slope and deflection in an elastic beam.

[3.0 Marks]

b) An arrangement of a beam set-up in a children park to support some playing equipment is shown in Fig. Q4. ABCD is a steel beam hanged at points B and C. Playing equipment are attached to the beam at free ends (i.e. A and D) and mid-span (i.e. E) with magnitudes P and 2P respectively. The cross section of the beam is varied along the length as indicated in Fig. Q4. Take young modulus of steel as E.

Note: Assume that the condition of equilibrium is static and there is no any deflection at the hanging points B and C.

Using Moment Area method, determine,

i) The slope of the beam at free ends under the given loading system

[4.0 Marks]

ii) The deflection at the mid span

[5.0 Marks]

Q5. A machine is operated by a motor and it transmits 50 kW power to a gear wheel through a hollow steel shaft as shown in Fig. Q5. The rotational speed of the shaft is 500 r.p.m and the allowable shear stress of the shaft material is 40 MPa.

a) If the outer diameter of the hollow shaft is restricted to 80 mm, determine the required wall thickness for the shaft.

[7.0 Marks]

b) If the hollow shaft is replaced by a solid shaft with an equivalent material, what is the safe diameter of the solid shaft to run the machine with the same motor at the same angular speed?

[5.0 Marks]

Hint: You may use $T=P/2\pi f$ formula with usual notations.

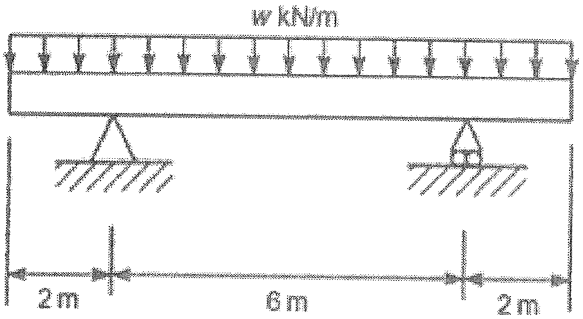
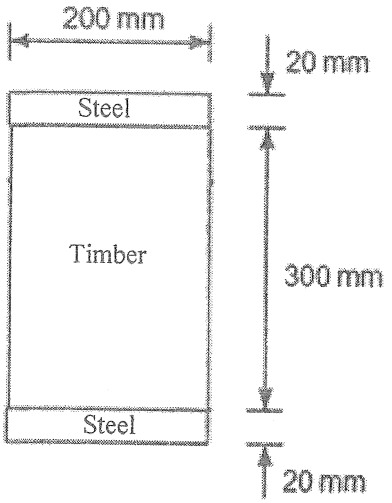


Fig. Q1 (a)



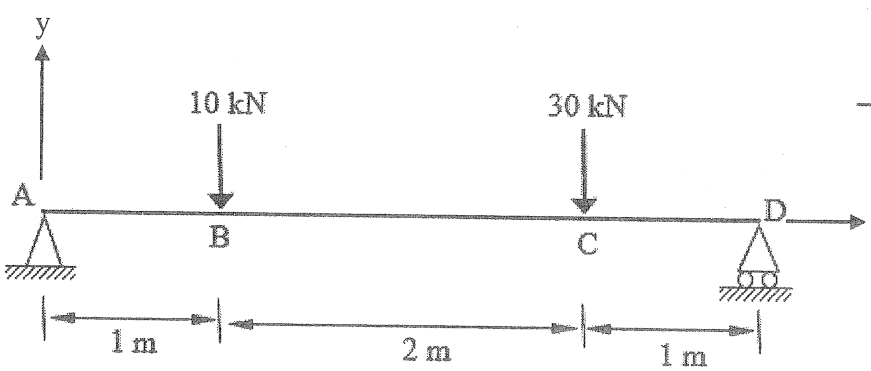


Fig. Q2 (a)

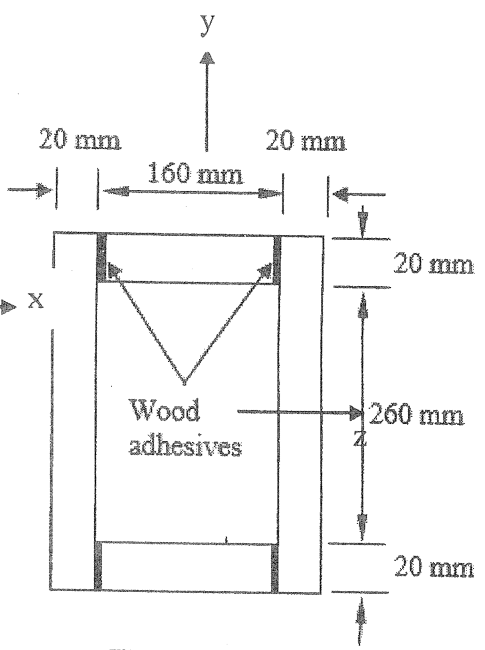


Fig. Q2 (b)

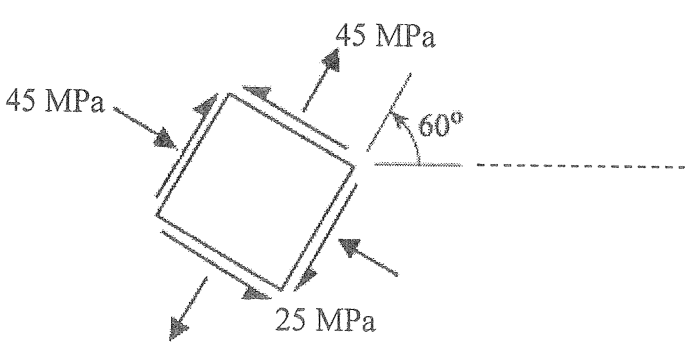


Fig. Q3 (a).

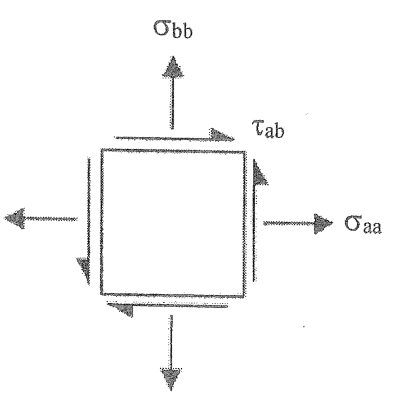
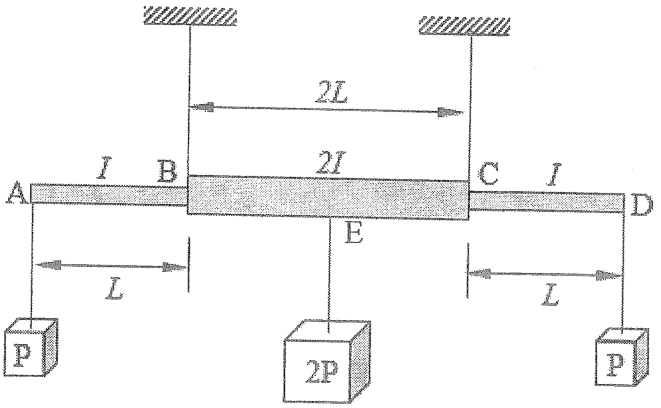


Fig. Q3 (b).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B
2I
C
I
A
D
E
L
L
P
2P
P

Fig. Q4

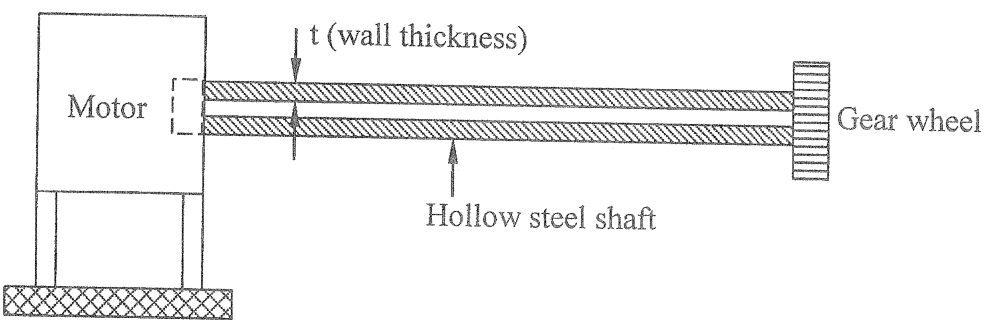
t (wall thickness)
Motor
Gear wheel
Hollow steel shaft

Fig. Q5