APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY		
THIRD SEMESTER B.TECH DEGREE		EXAMINATION, MAY2019
Course Code: CE201		
Course Name: MECHANICS OF SOLIDS		
Max. Marks: 100		Duration: 3 Hours

I **a)** Definition-1 mark

Volumetric strain =e_v =$\frac{3\sigma(1-2\mu)}{E}$ --------- (1) mark

= 4.62×10^{-4}----------------(1) mark

Change in volume =798.34 mm^3----------- (2) marks

b)Steel : Strain=3.75×10^{-4}

Stress=strain x E =75 N/mm^2

Also, stress=Load/Area ,Load =stress × Area =530N---(5)

Brass: Stress = Load/Area =168.7 N/mm^2

Strain=1.856×10^{-3}

E=stress/strain =90.89 kN/mm^2--------------------(5)

2 a) Statement ---(**3**) marks

Explanation with sketch ------------------------(**2**)marks

b) Total elongation $\delta l = \delta l_1 + \delta l_2 + \delta l_3$

$$=\frac{\sigma}{E}\left(\frac{l_1}{A_1} + \frac{l_3}{A_3} + \frac{4l_2}{\pi d_1 d_2}\right)$$

=0.555 mm------(4) marks

Total strain = 1.386x10^{-3}------------------------(2)marks

$\frac{\text{Stress}}{E} = strain\ of\ uniform\ bar$ =1.386×10^{-3}--------------------(2) marks

Load/Area = 1.386×10^{-3} × E

Area=$\frac{\pi d^2}{4}$ diameter = 10.71 mm -----------(2)marks

3a) Free expansion =Δ= $L_{cu}\alpha_{cu}t + L_s\alpha_s t$ = 0.92625 mm

Force in steel = force in copper

$\sigma_s A_s = \sigma_{cu} A_{cu}$----------- (2)marks

$\sigma_s = 1.5\sigma_{cu}$ ------(2)*marks*

Compression due to temperature stress = free expansion restricted

$\frac{\sigma_s}{E_s} * l_s + \frac{\sigma_{cu}}{E_{cu}} * l_{cu} = 0.92625$

$\sigma_s = 41.83$ N/mm^2

$\sigma_{cu} = 27.89$ N/mm^2

Reaction at the ends = $\sigma_s A_s = 41.83 \times 400 = 16.73$ N

b) Resilience(*definition*) *and* $\frac{\sigma^2}{2E} \times$ *Volume* ---(1)mark

proof Resilience(*definition*), $\frac{{\sigma_e}^2}{2E} \times$ *Volume*-----(2)marks

Modulus of resilience(*definition*) $(\frac{{\sigma_e}^2}{2E})$ --- (2)

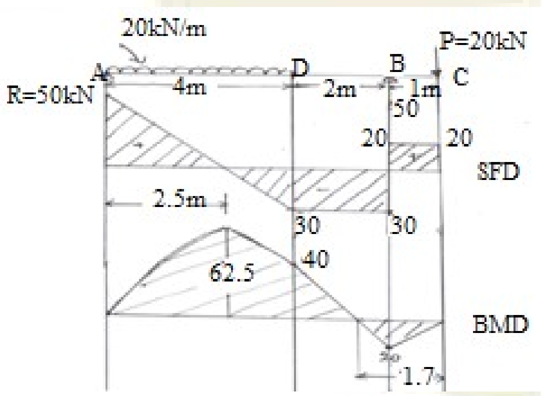
4a)(2) +(2)+(1) marks

b) P=20kN, R_A=R_B=50 kN--------- (2) marks

M_{max}=62.5 kN-m at 2.5m from A---- (2) marks

Point of contra flexure 1.67 m from C or 5.33 m from A----(2)marks

SFD-------(2) marks , BMD------(2) marks



5a) Definition (2) mark, sketch (1)mark

b)i) $R_A = 4$ kN

ii) $R_B = 8$ kN

iii) Bending moment at Section 2m from A (M)= 6 kN-m = 6×10^6 N-mm

iv)Location of Neutral axis =70.8 mm from bottom v)Distance to the extreme compression fiber from NA = Y_c=79.2mm

vi)Distance to the extreme tension fiber from NA = Y_t =70.8 mm (i-vi) carries 1 mark each

Moment of inertia about NA = 2.56×10^7 mm^4 (given)

Maximum Tensile stress (at bottom) = $\frac{M}{I}Y_t$= 16.59 N/mm^2------ (3) marks

Maximum compressive stress (at top) = $\frac{M}{I}Y_c$= 18.6 N/mm^2----- (3) marks

6a) Strain energy due to bending = U=$\int_0^l \frac{M^2dx}{2EI}$---(2) marks

= 44.4 kN-mm----(3) marks

b) Material1-steel

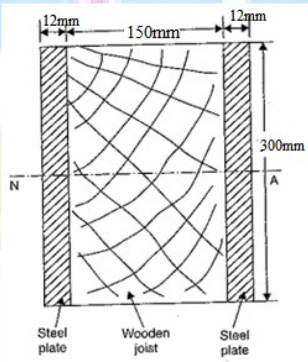
Material -2 Wood

Maximum Stress in wood =f_2 =8 N/mm^2

Maximum stress in steel at the same position= mf_2=(E_S/E_W)

f_2 =20×8=160N /mm^2-------(4) marks

Total moment of resistance = $\frac{f_2}{y_{max}}(I_2 + mI_1)$--------(2) marks



I_1 = 5.4×10^7mm^4 (MI of steel)–(1)mark

I_2 = 3.375×10^8 mm^4 (MI of wood)—(1)mark

y_{max} =150mm

Total Moment of resistance= 75.6 kN-m-------(2)mark

7a) Major principal stress = $\sigma_1 = \frac{1}{2}(\sigma_x + \sigma_y) + \frac{1}{2}\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau^2_{xy}}$ ---(2)marks

=75 N/mm^2 (given)

Shear stress on the given planes = 25N/mm^2-------(2) marks

Minor Principal stress= $\sigma_2 = \frac{1}{2}(\sigma_x + \sigma_y) - \frac{1}{2}\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau^2_{xy}}$

$=55$ N/mm^2(compressive)---(2)marks

Maximum shear stress$=\frac{\sigma_1-\sigma_2}{2}$ = (75+55)/2= 65 N/mm^2----(2) marks

Orientation of principal planes $=\theta_1=$ (1/2)tan^{-1}($\frac{2\tau_{xy}}{\sigma_x-\sigma_y}$)=11.3^0------(1) mark

$\theta_2=\theta_1+90^0=101.3^0$----(1) mark

Note:
Direction of principal planes can also be 78.7° and 168.7° since direction of shear stress is not specified. Full credit may be given if the student gets these values also.

b) Power transmitted $P=\frac{2\pi nT}{60}$

Material same ,(f_s)solid $=(f_s)$hollow

RPM same (n)solid =(n) hollow

$\frac{P_{hollow}}{P_{solid}}=\frac{T_{holl}}{T_{solid}}$ - - - - - -(1) mark

For solid shaft $\frac{T}{J}=\frac{f_s}{R}$

$T_{solid}=f_s\frac{J}{R}=\frac{f_s\pi d^3}{16}=1570796.3f_s$-------(2) marks

For hollow shaft

Area of solid shaft =Area of hollow shaft

Outer diameter = 250 mm-----(1) mark

$T_{hollow}=f_s\frac{J_{holl}}{R}=\pi(\frac{D_0^4-D_i^4}{16D_0})f_s=2670353.756f_s$ - - - -(2)marks

$\frac{P_{hollow}}{P_{solid}}=\frac{T_{hollow}}{T_{solid}}=\frac{2670353.756f_s}{1570796.3f_s}=1.7$ - - - -(2)marks

8a) longitudinal stress $f_2=\frac{Pd}{4t}\le 30$ N/mm^2

Thickness =50mm----------(2)marks

Hoop stress $f_1=\frac{Pd}{2t}\le 40$ N/mm^2

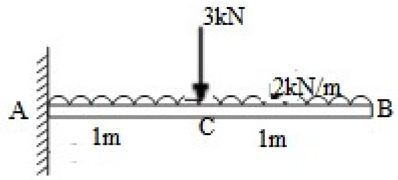
Thickness=75mm----(2)marks

Adopt thickness=75mm--------- (2) marks

b) Mohr's theorems statement i and ii-----(4) marks

c) $EI\frac{d^2y}{dx^2}=M_x=\quad -x^2\Big|-3(x-1)$----- (3)marks

C_1 =+25/6 and C_2 = -6.5 -------------- (3) marks



Deflection at the free end = 0.26 mm(↓)----(2) marks

Slope at the free end = 1.67×10^{-4} radians----(2) marks

9a) Kern of section-explanation (2) marks sketch (4) marks

b) Euler's theory

Critical load for one end hinged and other end fixed= $\frac{2\pi^2 EI}{l^2}$-----(2) mark

I=Minimum moment of inertia of the section =$\frac{1}{12}(DB^3 - db^3)$

D=500mm,d=460mm,B=250mm, b=210mm

I_{min}= 2.96×10^8 mm^4---(2)mark

P_E =8672.9 kN---(1)mark

Safe load = $P_E/4$= 2168.2 kN--------(2) mark

Rankine's Theory

$P_R = \frac{f_c * A}{1+\frac{1}{1600}\left(\frac{l_{eff}}{K_{min}}\right)^2}$-----(2)marks

l_{eff} = $8000/\sqrt{2} = 5656.25\ mm$---(1) mark

$K_{min} = \sqrt{\frac{Imin}{A}}$ =102.09mm----(1) mark

$P_R = \frac{600*28400}{1+\frac{1}{1600}\left(\frac{5656.85}{102.09}\right)^2}$= 5837.7kN-----(1) marks

Safe load = 5837.7/4= 1459.43kN--------(1) marks

P_E/P_R=2168.2 /1459.43 =1.485---(1) mark