Scheme of Valuation/Answer Key

(Scheme of evaluation (marks in brackets) and answers of problems/key)

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2018

Course Code: CE201

Course Name: MECHANICS OF SOLIDS

Max. Marks: 100 | Duration: 3 Hours

PART A

		Answer any two full questions, each carries 15 marks.	Marks
1	a)	(i) N= τ/φ (1 Mark) (ii) Proof resilience = $\sigma^2/2E$ where σ is the stress at elastic limit (1 Mark) (iii) Ultimate(yield load)/working load (1 Mark) (definition with formula)	(3)
	b)	$\delta l = \frac{\sigma}{E} \times l \;\; \Rightarrow \;\; \sigma = \frac{2.1 \times 2 \times 10^5}{3000}$ = 140 N/mm^2 (4 Marks) WD = SE $W(h + \delta l) = \frac{\sigma^2}{2E} \times A \times l$ (3 Marks) $\Rightarrow \;\; W = 17458$ N (1 Mark)	(8)
	c)	Concept of Bulk modulus - (1 Marks) Derivation (2 Marks). Formula: $E = 3K(1-2\nu)$ (1 Mark)	(4)
2	a)	Formula with explanation of the terms (i) $\delta l = \frac{4Pl}{\pi E d_1 d_2}$ (2 Marks) (ii) $\delta l = \frac{Pl}{Et(b-a)} \ln\left(\frac{b}{a}\right)$ (2 Marks)	(4)
	b)	(i) Stress = 156 N/mm^2 (2 marks) Pull = 110.27 kN (1 Mark) (ii) Stress = 108 N/mm^2 (3 marks) Pull = 76.34 kN (1 Mark)	(7)
	c)	$\sigma_{max} = 150 = \frac{P}{(\frac{\pi}{4} 15^2)} \;\; \Rightarrow \;\; P = 26.507 \times 10^3$ N (1 Mark) Stress in 20 mm dia portion = 84.375N/mm^2 (1 Mark) Strain energy formula (1 Mark) Strain energy in 20 mm dia portion = 2795.7 Nmm Strain energy in 15 mm dia portion = 2485 Nmm Total SE = 5280.7 Nmm (1 Mark)	(4)

<table>
<tr><td>3</td><td>a)</td><td>$\delta l = \dfrac{Pl}{AE} = 1.213\text{mm}$ (2 Marks)

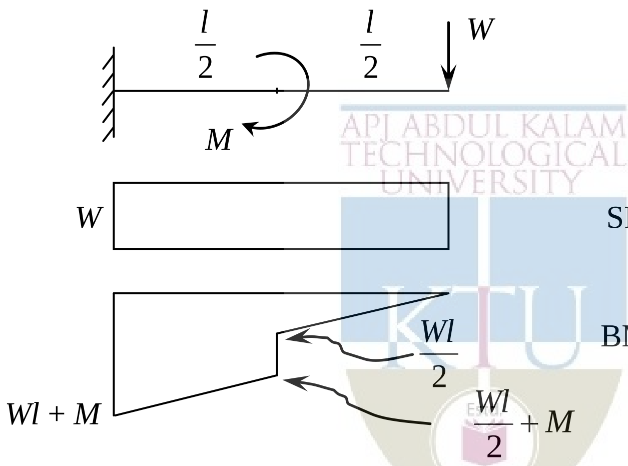
Poisson's ratio (ν) $= \dfrac{\left(0.00775/40\right)}{\left(1.213/2000\right)} = 0.32$ (2 Marks)

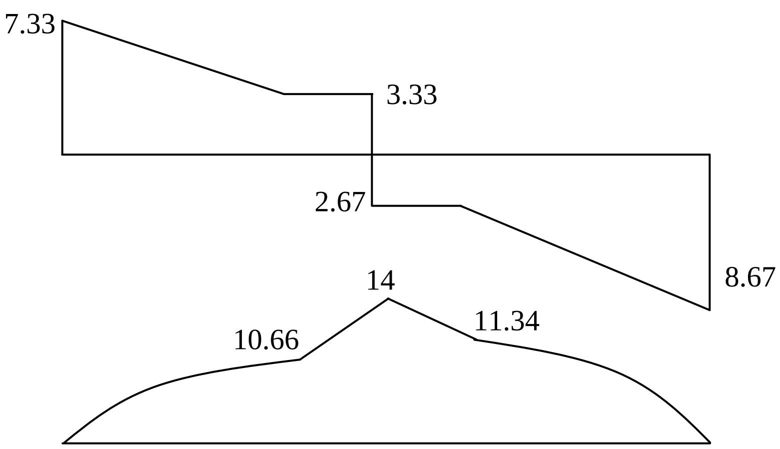
$E = 2N(1+\nu) \quad \Rightarrow N = 39.77\text{GPa}$ (2 Marks)</td><td>(6)</td></tr>
<tr><td></td><td>b)</td><td>Compatibility equation: $\dfrac{\sigma_s}{E_s} = \dfrac{\sigma_b}{E_b} \quad \Rightarrow \sigma_s = 1.818\sigma_b$ (3 Marks)

Equilibrium equation: $\sigma_s A_s + \sigma_b A_b = P \quad \Rightarrow \sigma_s + 1.133\sigma_b = 190.986$ (3 Marks)

Solving, σ_s = 117.66 N/mm^2 & σ_b = 64.72 N/mm^2 (1 Mark)

P_s = 554.4 kN & P_b = 345.6 kN (1 Mark)

$\delta l = 0.088$ mm (1 Mark)</td><td>(9)</td></tr>
<tr><td colspan="4">PART B</td></tr>
<tr><td colspan="4">Answer any two full questions, each carries 15 marks.</td></tr>
<tr><td>4</td><td>a)</td><td>

SFD - (2 Marks)
BMD - (3 Marks)</td><td>(5)</td></tr>
<tr><td></td><td>b)</td><td>Reactions R_A=7.33 kN; R_B= 8.67 kN (2 Marks)


SFD - (4 Marks)
BFD - (4 Marks)</td><td>(10)</td></tr>
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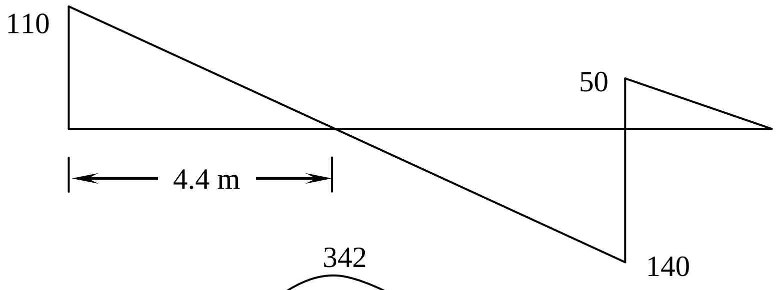
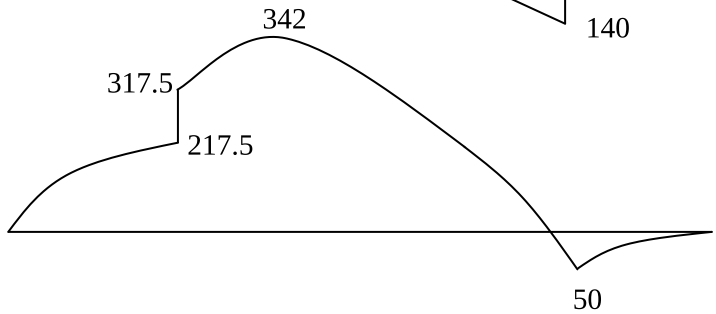
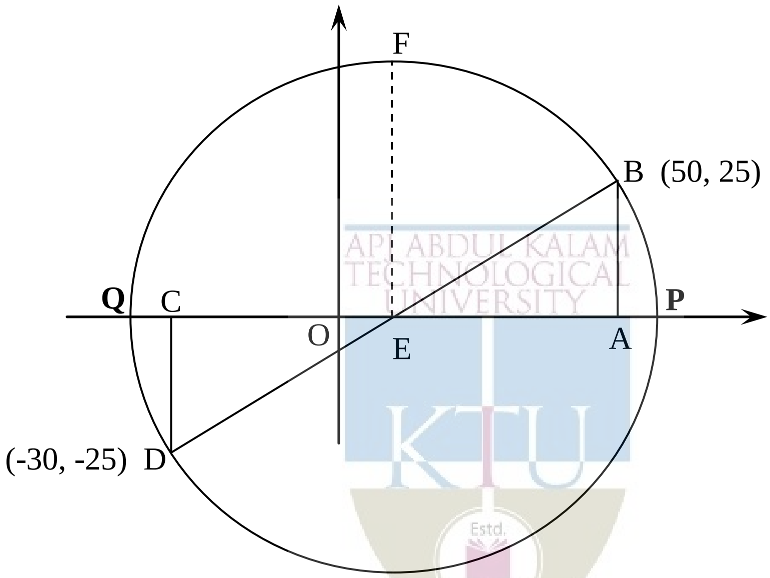
5	a)	Explanation + figure (3 Marks); Section modulus (2 Marks)	(5)
	b)	Reactions: $R_A = 110$ kN; $R_C = 190$ kN (3 Marks)  SFD - (3 Marks)  BMD - (4 Marks) *<u>Note:</u>- Since overhanging beam is not explicitly specified in the syllabus, full mark may be given, if 75% of SF & BM values are correct.*	(10)
6	a)	Explanation (3 Marks) & Sketch (2 Marks)	(5)
	b)	Calculation of max.BM = 1.5W kNm, (3 Marks) $I = \frac{100 \times 100^3}{36}$ (3 Marks) Correct equation: $\frac{M}{I} = \frac{\sigma}{y}$ (3 Mark) Allowable load (W) from both considerations: 2.778 kN and 4.167 kN Safe load= 2.778 kN & Extreme fibre stresses $\sigma_C = 100$ MPa; $\sigma_T = 50$ MPa (1 Marks) *<u>Note:</u>- Unsymmetrical section is not included the syllabus. Hence 90% mark is allotted for the basic steps.*	(10)
PART C			
Answer any two full questions, each carries20 marks.			
7	a)	Sketch showing the stresses in the element (1 Marks) Free body diagram & derivation (3 Marks) $\sigma_n = \sigma_x \cos^2\theta + \sigma_y \sin^2\theta$ (2 Marks) (Formula only - 2 mark)	(6)
	b)	Derivation of Circumferential stress, $\sigma_c = \frac{pd}{2t}$ (3 Marks)	(6)

		Derivation of Longitudinal stress, $\sigma_l = \dfrac{pd}{4t}$ (3 Marks) (Formulae only – 1½ × 2 = 3 marks)	
	c)	Shear stress consideration: $\dfrac{T}{J} = \dfrac{\tau_s}{R} \Rightarrow T = 752.2$ Nm Equation - (1 Mark); Value of T - (2 Mark) (J = 220644.95 mm^4; R = 22 mm) Angle of twist consideration: $\dfrac{T}{J} = \dfrac{G\theta}{l} \Rightarrow T = 205.4$ Nm Equation - (1 Mark); Value of T - (2 Mark) Selection of torque T = 205.4 Nm (1 mark) Power transmitted = 6022 Watts (1 Marks)	(8)
8	a)	 Mohr's circle (5 Marks) Major principal stress = OP = 57 N/mm^2(T) (1.5 Mark) Minor principal stress = OQ = 37 N/mm^2(C) (1.5 Mark) Max. Shear stress = EF = 47 N/mm^2 (1 Mark) Principal planes 16˚, 106˚ or 16˚, -74˚ (1 Mark) (*40% credit may be given, if the student finds correct answer using analytical method. Principal stresses – 2 marks, Max. Shear stress – 1 mark, Principal Planes – 1 mark*)	(10)
	b)	Essential points: *Double integration method*: Successive integration of $EI\dfrac{d^2y}{dx^2} = M(x)$ gives equation for slope & deflection. *Macaulay's method*: It is a double integration method in which $M(x)$ is the general BM expression. The appropriate terms are considered for a given	(4)

		segment. *Moment Area method*: Graphical method based on Mohr's theorems which use $\frac{M}{EI}$ diagram to compute slope & deflection (3 × 1 = 3 Marks) Additional points (1 Mark)	
	c)	Buckling load $P_{cr} = \frac{4\pi^2 EI}{l^2}$ OR $P_{cr} = \frac{\pi^2 EI}{L^2}$ where L is the eff. length = 0.5l. Formula (3 Marks) P_{cr} = 133870 kN (2 Marks) ($I = 2.5836\times10^8$ mm^4) Safe load = 38249 kN (1 Mark)	(6)
9	a)	Slenderness ratio = Effective length/Minimum radius of gyration (2 Marks) Kern of circular section – circular portion with diameter = d/4 Explanation with sketch (3 Marks)	(5)
	b)	Circumferential/hoop stress, Radial stress & Longitudinal stress (2 Marks) Circumferential stress, $\sigma_c = \frac{B}{x^2} + A$; Radial stress, $p_x = \frac{B}{x^2} - A$ Correct equations with detailing of the terms (2 +1 = 3 Marks)	(5)
	c)	Reactions R_{left} = 4.5 kN; R_{right} = 1.5 kN (1 Mark) $EI\frac{d^2y}{dx^2} = 1.5x \Big| -2\frac{(x-3)^2}{2}$ (2 Marks) Slope Equation: $EI\frac{dy}{dx} = 1.5\frac{x^2}{2} - 7.875 \Big| -\frac{(x-3)^3}{3}$ (2 Marks) Deflection Equation: $EI\,y = 1.5\frac{x^3}{6} - 7.875x \Big| -\frac{(x-3)^4}{12}$ (2 Marks) Slope at left = $\frac{10.125}{EI}$ = 0.00197 rad. Slope at right = $\frac{7.875}{EI}$ = 0.00253 rad. (2 Mark) Max. Deflection = $\frac{17.01}{EI}$ = 4.25 mm at x = 3.24 m from right. (1 Mark) <u>Note</u>:- *Full mark should be given if the student gets correct answers using any other method.*	(10)

75% credit may be given for correct procedure, even if answer is wrong, for any intermediate results.