TED (15) – 4014 Reg. No...

(REVISION — 2015) Signature ....

DIPLOMA EXAMINATION IN ENGINEERING/TECHNOLOGY/ MANAGEMENT/COMMERCIAL PRACTICE — APRIL, 2019

THEORY OF STRUCTURES – II

[*Time* : 3 hours

(Maximum marks : 100)

PART — A

(Maximum marks : 10)

Marks

I Answer *all* questions in one or two sentences. Each question carries 2 marks.

1. Define buckling load.
2. Name the two methods of determining the forces in a perfect frame.
3. Distinguish clearly direct stress and bending stress.
4. State Mohr's theorem-II.
5. Define stiffness factor and carry over factor. (5×2 = 10)

PART — B

(Maximum marks : 30)

II Answer any *five* of the following questions. Each question carries 6 marks.

1. How Rankine's formula is applicable for both short and long columns ?
2. A mild steel rod 50mm diameter and 3m long is used as a column whose one end is fixed and other end is hinged. If $E = 2\times10^5 N/mm^2$ and factor of safety = 4, determine the safe compressive load on the column.
3. A fixed beam AB of span L carries a point load W at mid span. Determine the fixing moments.
4. Discuss the conditions of stability of a dam.
5. A rectangular RC simply supported beam of span 3m and cross section 200×350 mm carries a point load of 125 KN at its mid span. Find maximum slope and deflection of the beam. Take $E = 2\times10^4 N/mm^2$.
6. A cantilever beam AB of length L carries a uniformly distributed load of w/unit length throughout the length. Find the slope and deflection at the free end by using Mohr's theorem.
7. Define the terms : (a) Fixed end moments (b) Unbalanced moment (c) Distributed moment. (5×6 = 30)

Marks

PART — C

(Maximum marks : 60)

(Answer *one* full question from each unit. Each full question carries 15 marks.)

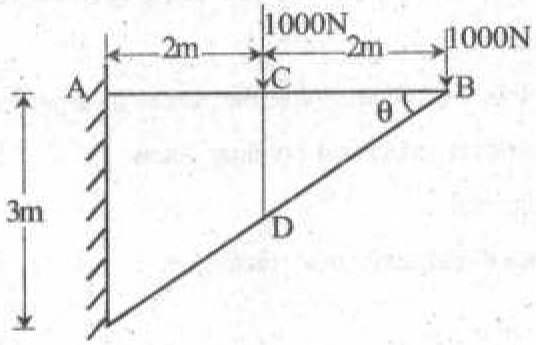
Unit — I

III (a) Determine the limiting length of a both ends hinged column of section 60×100 mm so that the ultimate crushing stress is $250 N/mm^2$. Assume Young's modulas $E = 2\times10^5 N/mm^2$. 7

(b) A column in a framed structure is formed of mild steel pipe 200mm external diameter and 10 mm thick. It has 3m long and it's both ends are hinged. Taking factor of safety as 4, find the safe load that can be applied on the column. Take $f_c = 330 N/mm^2$ and Rankine's constant $\alpha = 1/1600$ 8

Or

IV Determine the forces in the members of the truss shown below.



15

Unit — II

V (a) Explain the term limit of eccentricity and derive the expression for eccentricity for a solid circular section. 7

(b) A mild steel tube 4m long, 30mm internal diameter and 4mm thick is used as a strut with both ends are hinged. Find the crippling load if ;

(i) Both ends are fixed (ii) One end is fixed and other end is free

(Take $E = 2\times10^5 N/mm^2$) 8

Or

VI (a) Determine the fixing moments and draw the BM and SF diagram of a fixed beam AB of span 5m carrying a uniformly distributed load of 10KN/m throughout the span. 7

(b) The back fill of a masonry retaining wall having trapezoidal section is vertical. The height of the wall is 12m and it retains earth up to its top. If the top width of the wall is 4m, determine its base width. Assume weight of earth as $18 KN/m^3$ and that of masonry as $22KN/m^3$. Take $\varnothing = 45^0$. 8

Unit — III

VII (a) A cantilever beam 120mm wide and 200mm deep is 2.50m long. Find the uniformly distributed load the beam should carry to produce a deflection of 5mm at its free end. Take $E = 2\times10^5 N/mm^2$. 7

Marks

(b) A beam simply supported at its both ends carries a uniformly distributed load of 16KN/m. If the deflection of the beam at its center is limited to 2.5mm, find the span of the beam. Take flexural rigidity EI for the beam as $9\times10^{12}N/mm^2$. 8

OR

VIII (a) Using double integration method, derive the expressions for a cantilever beam AB of length L carrying a point load at the free end. 7

(b) A simply supported rectangular RC beam of span 4m and cross section 150mm×300mm is carrying a uniformly distributed load of 10 KN/m throughout the span and a point load of 50KN at its mid span. Find the maximum slope and deflection of the beam. Take $E = 2\times10^4 N/mm^2$. 8

UNIT — IV

IX A continous beam ABC are of span length AB = 4m and BC = 6m. The portion AB carries a uniformly distributed load of 60KN/m and the portion BC carries a uniformly distributed load of 100KN/m. If all the supports are simply supported, draw the SF and BM diagram. 15

OR

X A beam ABC is fixed at A and C and simply supported at B. The span AB carries a point load of 15KN at its center. The span BC carries a uniformly distributed load of 10KN/m. If AB = 5m and BC = 4m, draw the SF and BM diagram by moment distribution method. 15

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23 D

Scoring Indicators

THEORY OF STRUCTURES – II

Code : 4014 (TED:15) **Version:** C

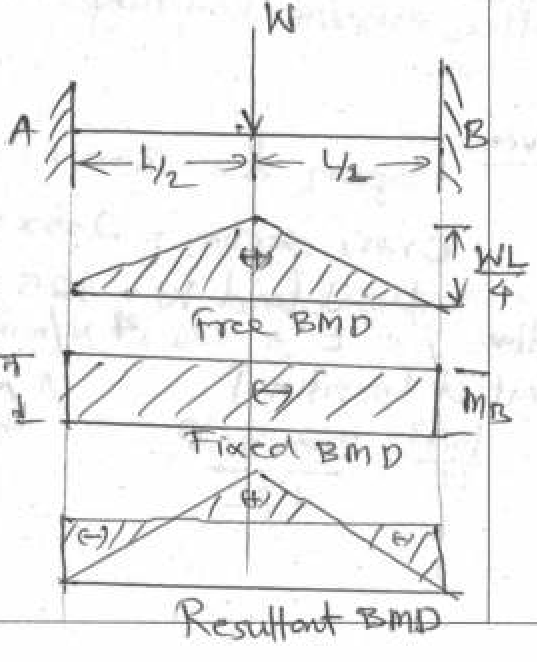
Qn. No.	Scoring Indicators	Split score	Total score
	Part – A		
	Each question carries – 2 marks.		
1.	1) buckling load: The limiting load at which the column starts buckles. Also called crippling or critical load	2	
	2) i) method of joint ii) method of section iii) Graphical method. – Any two	2	
	3) Direct & bending stress: Direct stress:- when a vertical load acts on a column ~~or strut~~ through the cg of the section direct stress occurs uniformly throughout the section at base. But when the loading is eccentric, bending moment also develops in the column and consequently bending stress acts at the base section of the column	2	
	4) Mohr's theorem – II : States that the intercept taken on a vertical reference line by tangent at any two points on an elastic curve is equal to the moment of the BM diagram between these points about the reference line divided by EI.	2	
	5) i) Stiffness factor: It is the moment required at one end of a member to produce a unit angle of rotation at that end. ii) Carry over factor: It is the ratio of moment applied at one end joint of a member to the moment induced at its other end joint (1+1)	2	

Code : Version:

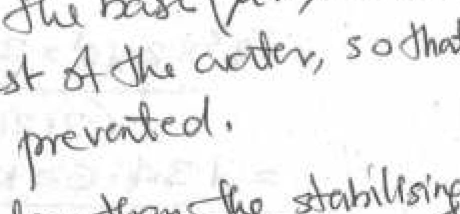
Qn. No.	Scoring Indicators	Split score	Total score
	Part-B		
	~~E~~ Answer any ~~5~~ five questions - Each carries 6 marks		
II 1)	Rankine's formula:-		
	Eulers formula gives correct result only for very long columns - short columns fails mainly due to direct crushing - medium column which are neither long ~~or~~ nor short fail by both buckling and direct crushing.		
	Rankine derived an emperical formula based on practical experiments for determining the crippling load, which is applicable to all columns irrespective of whether short or long	2	
	By Rankine's formula	1	
	$\frac{1}{P} = \frac{1}{P_C} + \frac{1}{P_E}$		
	where P - Crippling load by Rankine P_C - ultimate crushing load of column material P_E - Crippling load by Euler's formula	1	
	For short column P_E will be high and $\frac{1}{P_E}$ is very small	1	
	$\therefore \frac{1}{P} = \frac{1}{P_C}$		
	For ~~long~~ long column P_E will be small ~~and~~ ~~hence~~ and $\frac{1}{P_E}$ is large compared to $\frac{1}{P_C}$	1	6.
	$\therefore \frac{1}{P} = \frac{1}{P_E}$		

Scoring Indicators

Code : **Version:**

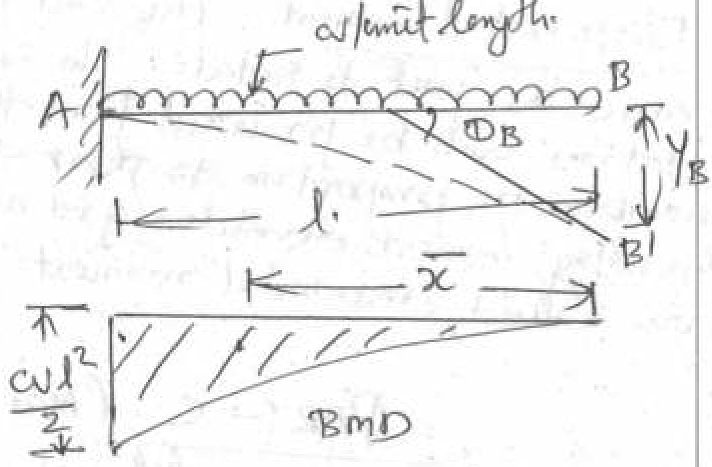
Qn. No.	Scoring Indicators	Split score	Total score
2)	Given: diameter $d = 50\ mm$. length $l = 3m = 3\times10^3\ mm$ $E = 2\times10^5\ N/mm^2$ factor of safety $S = 4$ Solution:- End condition: One end fixed and other ~~free~~ hinged $\therefore$ eff. length $L = \frac{l}{\sqrt{2}} = \frac{3\times10^3}{\sqrt{2}} = 2121.32\ mm$ moment of Inertia $I = \frac{\pi}{64} d^4 = \frac{\pi}{6}\times 50^4 = 306796.15\ mm^4$ $\therefore$ Crippling load $P_E = \frac{\pi^2 EI}{L^2}$ $= \frac{\pi^2\times2\times10^5\times306796.15}{(2121.32)^2} = 134575.89\ N$ $= 134.60\ kN$ $\therefore$ Safe comp. load on the column $= \frac{134.60}{4}$ $= 33.65\ kN$	 1 1 3 1	 6
3)	Area of free BMD $A_1 = \frac{1}{2}\times L\times\frac{WL}{4} = \frac{WL^2}{8}$ centroidal dist. from A, $x_1 = L/2$ Area of fixed BMD $A' = L M_A$ $A_2 = A_1$ $\therefore L M_A = \frac{WL^2}{8}$ $\therefore M_A = \frac{WL}{8}$  		

Code : **Version:**

Qn. No.	Scoring Indicators	Split score	Total score
	since $M_A = M_B$ (symmetrical loading).		
	$\therefore M_A = M_B = \frac{WL}{8}$		
	with the values of M_A, M_B the BMD is drawn by over lapping the free BMD. (Derivation - 3 + fig 3)		6.
4)	Conditions of stability of a dam:		
	1) Resultant thrust cuts the base within middle third of the base width to avoid tensile stress at the base	$1\frac{1}{2}$	
	2) max. comp stress in the masonry is never allowed to be more than its permissible limits to prevent crushing of the dam material.	$1\frac{1}{2}$	
	3) max. frictional force at the base (μW) is more than the horizontal thrust of the water, so that sliding at the base is prevented.	$1\frac{1}{2}$	
	4) Over turning moment is less than the stabilising moment for no overturning. The minimum base width of dam is worked out equating the above limiting condition.	$1\frac{1}{2}$	6.
5)	Given: Span $l = 3m = 3000$ mm.		
	Cross section $= 200 \times 350$ mm.		
	Point load $W = 125$ kN $= 125 \times 10^3$ N.		
	Solution: $E = 2 \times 10^4$ N/mm^2 Y_c		
	Moment of Inertia I		
	$I = \frac{bd^3}{12} = \frac{200 \times 350^3}{12}$		
			

Scoring Indicators

Code : **Version:**

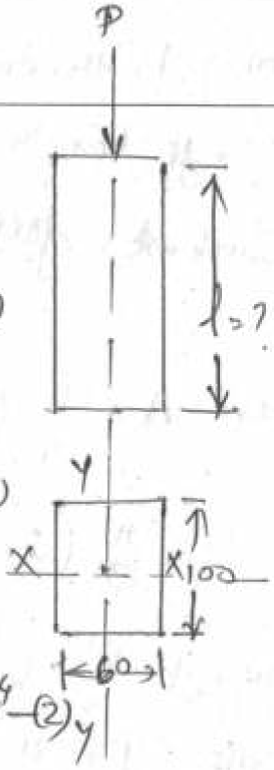
Qn. No.	Scoring Indicators	Split score	Total score
	$\cancel{I_{xx}} = 71.45\times10^{7}\ mm^4$	1	
	max. slope at support		
	~~(∴ symmetr~~ $\theta_A = \theta_B = \frac{WL^2}{16EI} = \frac{125\times10^3\times(3000)^2}{16\times2\times10^4\times71.45\times10^7}$		
	$= 4.92\times10^{-3}$ radian		
	$= 0^\circ 16' 55''$	2+1	
	max. deflection at 'C' $y_c = \frac{WL^3}{48EI}$		
	$= \frac{125\times10^3\times(3000)^3}{48\times2\times10^4\times71.45\times10^7} = 4.92\ mm$	2	6
6)			
	Area of BM diagram $= \frac{wl^2}{2}\times l\times\frac{1}{3}$		
	$= \frac{wl^3}{6}$	1	
	distance of CG of BMD from B		
	$\bar{x} = \frac{3}{4}l$	1	
	According to Mohr's theorem I		
	change of slope between A & B		
	$\theta_B = \frac{A}{EI} = \frac{wl^3}{6EI}$ radian	2	

Qn. No.	Scoring Indicators	Split score	Total score
	According to Mohr's theorem II Intercept of the tangent on A & B is $BB' = Y_B$ $Y_B = \frac{A\bar{x}}{EI} = \frac{\frac{wl^3}{6}\times\frac{3}{4}l}{EI} = \frac{wl^4}{8EI}$	2	6.
7)	a) Fixed end moment: The moment induced at the ends of a member due to the applied load considering the member to be fixed at both the ends	2	
	b) Unbalanced moment: The algebraic sum of the moments meeting at a joint	~~2~~ 1	
	c) Distributed moment: The unbalanced moments cause the joint to rotate. The resistance to rotation will be provided from the ~~mber~~ member in proportion to their stiffness. The resisting moments ~~devel~~ developed in the members are called distributed moment	3	6.
	PART-C (Max. mark: 60) ~~Answer~~ Answer one full question from each unit each carries 15 marks.		
III	a) Given: Column size = 60x100 mm ultimate crushing stress $f_c = 250\ N/mm^2$ $E = 2\times10^5\ N/mm^2$		

Scoring Indicators

Code : **Version:**

Qn. No.	Scoring Indicators	Split score	Total score
	Solution:		
	Area of column section $A = 60 \times 100$ $= \underline{6000\ mm^2}$ —(1)	1	
	$\therefore$ Critical load $P_c = f_c \cdot A$ $= 250 \times 6000 = \underline{1500\ kN}$ —(1)	1	
	Least MI of the section $I_{min} = I_{yy} = \frac{100 \times 60^3}{12} = \underline{18 \times 10^5\ mm^4}$ —(2)	2	
	Since both ends are hinged $\therefore$ effective length $L = l$. By Euler's formula $P_E = P_c = \frac{\pi^2 EI}{l^2}$ $\therefore 1500 \times 10^3 = \frac{\pi^2 \times 2 \times 10^5 \times 18 \times 10^5}{l^2}$ $\therefore l = 1589\ mm = \underline{1.59\ mtr}$ →	3	7.
	b) Given: External dia $d_1 = 200\ mm$; thickness $t = 10\ mm$; length $l = 3\ m = 3000\ mm$; factor of safety $S = 4$; $f_c = 330\ N/mm^2$; Rankine's Const $\alpha = 1/1600$		



Code :　　　　　　　　　　　　　　　　　　　　Version:

Qn. No.	Scoring Indicators	Split score	Total score
	Solution: both ends are hinged		
	$\therefore$ eff. length $L = l = 3000$ mm	1	
	By Rankine's formula $P = \dfrac{f_c \cdot A}{\left[1+\alpha\left(\frac{l}{k}\right)^2\right]}$	1	
	where $A = \frac{\pi}{4}(d_1^2 - d_2^2)$ $\left[d_2 = 200-20 = 180\text{ mm}\right]$		
	$= \frac{\pi}{4}(200^2 - 180^2) = 5969.\text{ mm}^2$	1	
	radius of $k = \sqrt{I/A}$		
	when $I = \frac{\pi}{64}(d_1^4 - d_2^4) = \frac{\pi}{64}(200^4 - 180^4)$		
	$= 27 \times 10^6\text{ mm}^4$	1	
	$\therefore k = \sqrt{\frac{27\times10^6}{5969}} = 67.25$ mm.	1	
	$\therefore$ Buckling load $P = \dfrac{330 \times 5969}{\left[1+\frac{1}{1600}\left(\frac{3000}{67.25}\right)^2\right]}$		
	$= 877886.48$ N		
	$= 877.90$ kN	2	
	$\therefore$ Safe load on column $= \frac{877.90}{4} = 219.48$ kN	1	8

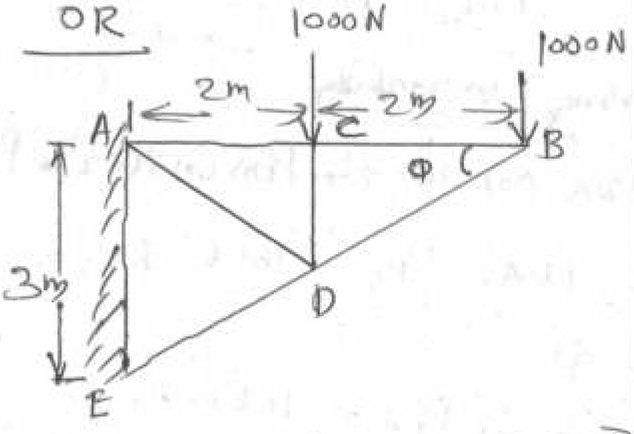
Scoring Indicators

Code : **Version:**

Qn. No.	Scoring Indicators	Split score	Total score

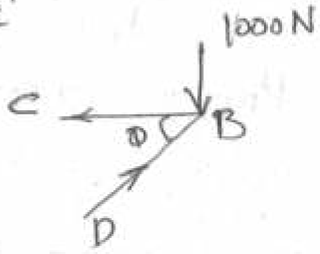
IV

OR



Solution: — 2

$\tan \Phi = \frac{3}{4}$ $\therefore \Phi = 36^\circ 52'$



Joint B

Resolving vertically

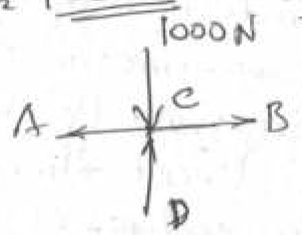
$P_{BD} \sin \Phi = 1000$

$\therefore P_{BD} = \underline{1666.79}$ KN (C)

Resolving horizontally

$P_{BC} = P_{BD} \cos \Phi$

$= 1666.79 \cos 36^\circ 52' = \underline{\underline{1333.46}}$ (T) → 3



Joint C : Resolving vertically

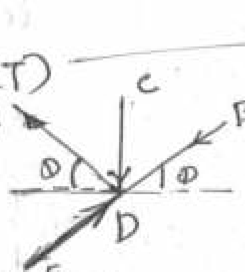
$1000 = P_{CD}$

$\therefore P_{CD} = 1000$ N (C).

Resolving horizontally

$P_{CB} - P_{CA} = 0$

$\therefore P_{CA} = P_{CB} = \underline{1333.46}$ (T) — 3



Joint D

Resolving vertically

$P_{DE} \sin \Phi + P_{DA} \sin \Phi - P_{DC} - P_{DB} \sin \Phi = 0$

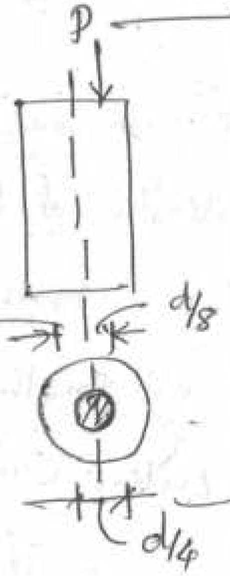
$P_{DE} \sin 36^\circ 52' + P_{DA} \sin 36^\circ 52' - 1000 - 1666.79 \sin 36^\circ 52'$

Code : Version:

Qn. No.	Scoring Indicators	Split score	Total score
	~~$\therefore P_{DE} + P_{DA} =$~~		
	$\therefore P_{DE} + P_{DA} = \frac{2000}{\sin 36^\circ 52'} = 3333.58$ — (1)	3	
	Resolving horizontally		
	$P_{DA} \cos 36^\circ 52' + P_{DB} \cos 36^\circ 52' - P_{DE} \cos 36^\circ 52' = 0$		
	$\therefore P_{DA} - P_{DE} = 1666.79$ — (2).		
	Solving (1) & (2)		
	$2 P_{DA} = 1666.79$		
	$\therefore P_{DA} = 833.40$ kN (T)		
	$\therefore P_{DE} = 3333.58 - 833.40 = 2500.18$ kN (C)	4	15
	UNIT – VI		
V	a) Limit of eccentricity: In an eccentrically loaded column, both direct and bendg stress are simultaneously developed. Bending stress may be compressive or tensile. Direct stress is always compressive. If bending stress is equal or less than direct stress then no tensile stress developed in the section which is always desirable for structural safety		
	ie $f_b \leq f_d$		
	or		
	$\frac{M}{Z} \leq P/A$		
	or $\frac{Pe}{Z} \leq P/A$ or $e \leq \frac{Z}{A}$		

Scoring Indicators

Code : **Version:**

Qn. No.	Scoring Indicators	Split score	Total score
	where P – eccentric load. e – eccentricity. Z – modulus of section, A – cross sectional area	3	
	b) for a solid circular section  For no tension develops in the base section Limit of eccentricity $e \leq \frac{Z}{A}$ where $Z = \frac{\pi}{32} d^3$ and Area $A = \frac{\pi}{4} d^2$	1	
	$\therefore e \leq \frac{\pi}{32} d^3 / \frac{\pi}{4} d^2$ $\therefore e \leq \frac{d}{8}$ ie limit of eccentricity on either side of XX or YY axis is $\frac{d}{8}$	3	7
	b) Given: length of column $l = 4m = 4000$ mm, Internal dia $d_2 = 30$ mm, thickness 't' = 4 mm, $E = 2\times10^5 N/mm^2$. Solution: extr. dia $d_1 = 30+4+4 = 38$ mm. least moment of Inertia $I = \frac{\pi}{64}(d_1^4 - d_2^4)$ $= \frac{\pi}{64}(38^4 - 30^4) = 62593$ mm^4.	2	
	~~Case-1 : both ends are hinged.~~		

Code : Version:

Qn. No.	Scoring Indicators	Split score	Total score
	~~Eff. length $L = l = 4000$ mm~~		
	~~$\therefore$ Crippling load $P_E = \frac{\pi^2 EI}{L^2} = \frac{\pi^2 \times 2\times10^5 \times 62593}{(4000)^2} = 7722.10N = 7.72$ kN~~		
	~~Case-2 : One end fixed other free~~		
	~~eff. length of $L = \frac{l}{2} = \frac{4000}{2} = 2000$ mm.~~		
	Case-1 : Both ends are fixed		
	$\therefore$ eff. length $L = \frac{l}{2} = \frac{4000}{2} = 2000$ mm.		
	$\therefore$ Eulers Crippling load $P_E = \frac{\pi^2 EI}{L^2}$		
	$= \frac{\pi^2 \times 2\times10^5 \times 62593}{(2000)^2} = 30.88$ kN	3	
	Case-2: ~~Both ends are~~ One end of column fixed and other end free		
	$\therefore$ eff. length $L = 2l = 2\times4000 = 8000$ mm.		
	$\therefore P_E = \frac{\pi^2 \times 2\times10^5 \times 62593}{(8000)^2} = 1930.52N$ or $= 1.93$ kN	3	8
	OR		
VI 9)	Given : ~~Span AB =~~		
	Span $l = 5$ m $= 5000$ mm		
	udl load $w = 10$ kN/m .		

Scoring Indicators

Code : **Version:**

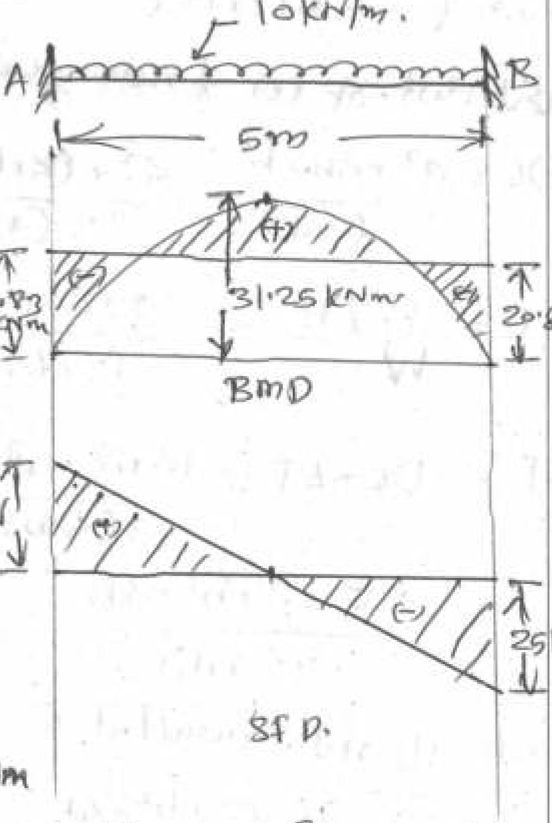
Qn. No.	Scoring Indicators	Split score	Total score

from symmetry of loading

$R_A = R_B = \frac{wl}{2}$

$= \frac{50}{2} = \underline{25\ kN}$

knowing the values, R_A & R_B SFD can be drawn.



Illy

Fixing moments at A, B

$M_A = M_B$ (Symmetrical loading)

$M_A = M_B = \frac{wl^2}{12}$

$= \frac{10 \times 5^2}{12} = \underline{20.83\ kNm}$

Free BM at Mid span $= \frac{wl^2}{8} = \frac{10 \times 5^2}{8} = 31.25\ kNm$.

knowing the values M_A, M_B & free BM at C the BMD can be drawn.

1+2+2+ diagram 2 } 7

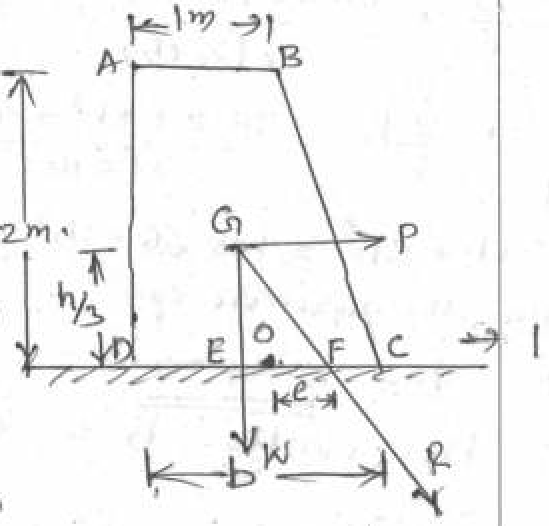
b) Given:

Height of retaining wall $h = 12m$

top width $a = 4m$.

$w = 18\ kN/m^3$ (unit wt of earth)

$\rho = 22\ kN/m^3$ (" of masonry)



Solution:

~~Total P~~

Total load of earth fill 'P'

$P = \frac{wh^2}{2} \times \frac{1 - \sin\phi}{1 + \sin\phi} = \frac{18 \times 12^2}{2} \times \frac{1 - \sin 45°}{1 + \sin 45°} = 2$

$= \underline{\underline{222.36\ kN}}$ — P

Code :

Version:

Qn. No.	Scoring Indicators	Split score	Total score
	weight of masonry wall per meter length		
	$W = \left(\frac{4+b}{2}\right) \times 12 \times 1 \times 22 = 132(4+b)$ kN $\rightarrow$	1	
	Horizontal dist. of CG of retaining wall from vertical face AD		
	$DE = \frac{a^2+ab+b^2}{3(a+b)} = \frac{4^2+(4\times b)+b^2}{3(4+b)} = \frac{16+b^2+4b}{3(4+b)}$ —	1	
	$EF = \frac{P}{W} \times \frac{h}{3} = \frac{222.36}{132(4+b)} \times \frac{12}{3} = \frac{6.74}{(4+b)}$ -		
	$DF = DE + EF = \frac{16+b^2+4b}{3(4+b)} + \frac{6.74}{(4+b)}$		
	$= \frac{36.22+b^2+4b}{3(4+b)}$		
	eccentricity of the resultant R, 'e' $= DF - \frac{b}{2}$		
	$= \frac{36.22+b^2+4b}{3(4+b)} - \frac{b}{2}$ —	1	
	To avoid tension at the base of retaining wall		
	$e = \frac{b}{6}$		
	$\therefore \frac{b}{6} = \frac{36.22+b^2+4b}{3(4+b)} - b/2$ $\longrightarrow$	1	
	$\therefore \frac{2}{3}b = \frac{36.22+b^2+4b}{3(4+b)}$		
	Solving:		
	$24b + 6b^2 = 108.66 + 3b^2 + 12b$		
	solving the quadratic eqn		
	$b = \underline{\underline{4.34 \text{ m}}}$		
	$\therefore$ base width $b = 4.34$ m. $\longrightarrow$	2	8

Scoring Indicators

Code : **Version:**

Qn. No.	Scoring Indicators	Split score	Total score
	UNIT – III		
VII a)	Given:		
	Size of beam: 120 x 200.		
	Span $l = 2.50\ m = 2500\ mm$.		
	deflection $Y_B = 5\ mm$.		
	$E = 2\times10^5\ N/mm^2$. 	1	
	Solution:		
	For a cantilever beam with udl deflection at free end,		
	$Y_B = \frac{wl^4}{8EI}$	1	
	$\therefore 5 = \frac{w\times(2500)^4}{8EI}$		
	where $I = \frac{bd^3}{12} = \frac{120\times200^3}{12} = 8\times10^7\ mm^4$	1	
	$\therefore 5 = \frac{w\times(2500)^4}{8\times2\times10^5\times8\times10^7}$		
	$\therefore w = 16.38\ N/mm = 16.40\ KN/m$	4	7
b)	Given: 	2	
	udl load $w = 16\ KN/m$		
	~~defl.~~ deflection at mid 'C', $Y_C =$ ~~2mm~~ 2.50 mm.		
	Flexural rigidity $EI = 9\times10^{12}\ N\text{-}mm^2$.		

Code : **Version:**

Qn. No.	Scoring Indicators	Split score	Total score

Solution:

Simply supported beam with udl

max. deflection at centre 'C'; $Y_c = \frac{5wl^4}{384EI}$ → 3

$\therefore 2.50 = \frac{\cancel{5\omega l}\ 5 \times 16 \times l^4}{384 \times 9 \times 10^{12}}$

$\therefore l^4 = \cancel{1.08 \times 10^{14}\ mm}$

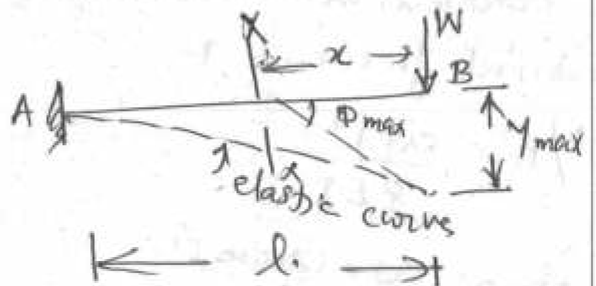
$= \cancel{1.08 \times 10^{11}\ m}$

$\therefore l = \underline{\underline{3.22\ mtr.}}$ → 3 — 8.

OR

VIII

a)



Consider a cantilever AB of leng 'l' carrying point load 'W' at its free end 'B'.

BM at a distance 'x' from B $M_x = -Wx$.

equation for elastic curve $EI\frac{d^2y}{dx^2} = M_x = -Wx$ — ① — 1

Slope: Integrating eqn (1) w.r.to x

$EI\frac{dy}{dx} = -\frac{Wx^2}{2} + C_1$ — ②

where C_1 is integration constant.

slope at fixed end is zero

$\therefore$ At $x = l$ and $\frac{dy}{dx} = 0$

using this relation in eqn ②

Scoring Indicators

Code : **Version:**

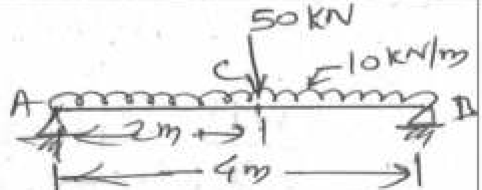
Qn. No.	Scoring Indicators	Split score	Total score
	$0 = -\frac{Wl^2}{2} + C_1$ $\therefore C_1 = \frac{Wl^2}{2}$, putting this value in eqn (2) $EI\frac{dy}{dx} = -\frac{Wx^2}{2} + \frac{Wl^2}{2}$ $\therefore \frac{dy}{dx} = \frac{W}{2EI}(l^2 - x^2) \longleftarrow (3)$ For max. slope at 'B' substitute $x = 0$ in eqn (3) $\theta_{max} = \frac{W}{2EI}(l^2 - 0^2) = \frac{Wl^2}{2EI}$	3	
	Deflection: Integrating eqn (3) w.r.to x. $Y = \frac{W}{2EI}\left(l^2x - \frac{x^3}{3}\right) + C_2 \longleftarrow (4)$ Where C_2 – Integration constant. At fixed end A $x = l$ and $Y = 0$. using this condition in eqn (4) $0 = \frac{W}{2EI}\left(l^2.l - \frac{l^3}{3}\right) + C_2$ $\therefore C_2 = \frac{-Wl^3}{3EI}$, putting the value of '$C_2$' in equation (4) $Y = \frac{W}{2EI}\left(l^2x - \frac{x^3}{3}\right) - \frac{Wl^3}{3EI}$ — 5. For max deflection at 'B', $x = 0$. $\therefore Y_{max} = \frac{W}{2EI}(0) - \frac{Wl^3}{3EI}$ $\therefore Y_{max} = \frac{(-)Wl^3}{3EI}$	3	7

Code : **Version:**

Qn. No.	Scoring Indicators	Split score	Total score

b)

Given:



span $l = 4m = 4000$ mm.

point load $W = 50KN = 50000N$

udl 'ω' $= 10kN/m = 10 N/mm$, $E = 2\times10^4 N/mm^2$

m.I of the section $I = \frac{150\times300^3}{12} = 33.75\times10^7$ mm^4 — 1

max. slope occurs at end & max. deflection at centre

max. slope

$$\theta_{max} = \frac{Wl^2}{16EI} + \frac{\omega l^3}{24EI}$$

$$= \frac{50\times10^3\times(4\times10^3)^2}{16\times2\times10^4\times33.75\times10^7} + \frac{10\times(4\times10^3)^3}{24\times2\times10^4\times33.75\times10^7} \rightarrow 3$$

$$= 0.0114 \text{ radian.} \rightarrow 1$$

$\theta_A = \theta_B = 0^\circ 39' 11''$

max. deflection

at 'c' $\quad Y_{max} = \frac{Wl^3}{48EI} + \frac{5\omega l^4}{384EI}$

$$\therefore Y_{max} = \frac{50\times10^3\times(4\times10^3)^3}{48\times2\times10^4\times33.75\times10^7} + \frac{5\times10\times(4\times10^3)^4}{384\times2\times10^4\times33.75\times10^7} \rightarrow 3 \qquad 8$$

$Y_{max} = 14.82$ mm.

UNIT – IV

IX

Given: span AB (l_1) $= 4m$, BC (l_2) $= 6m$ } Simply supported.

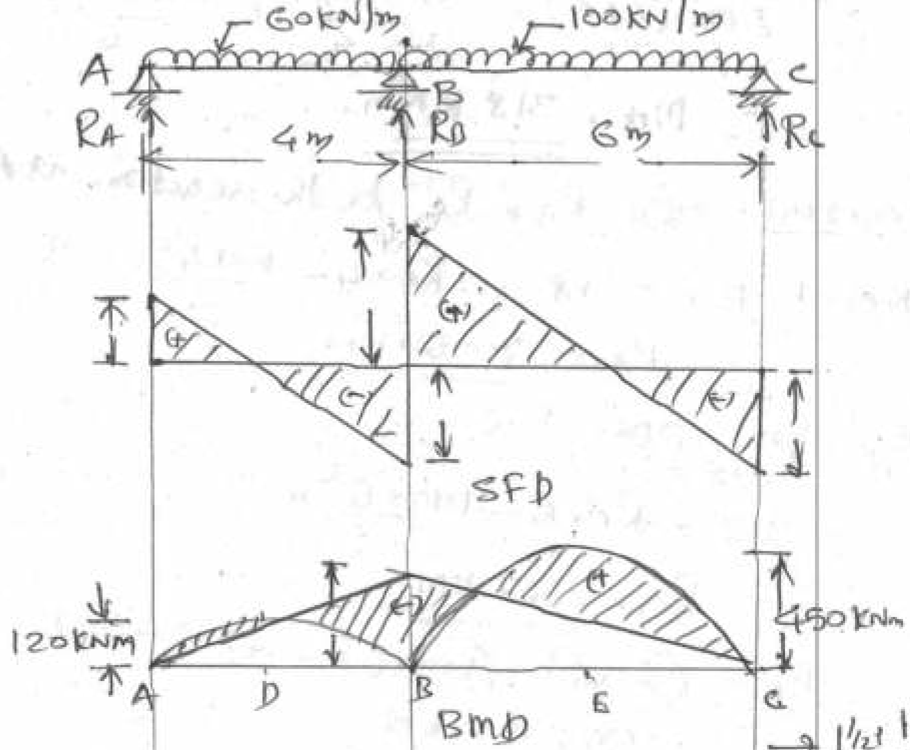
(for span AB) $\omega_1 = 60 kN/m$

" BC $\omega_2 = 100 kN/m$.

Scoring Indicators

+

Code : **Version:**

Qn. No.	Scoring Indicators	Split score	Total score
		→ 1½ 1½ 3	
	Span AB $L_1 = 4m$ " BC $L_2 = 6m$		
	for span AB max free BM at D $= \frac{60 \times 4^2}{8} = 120 kNm$	1	
	" BC " at E $= \frac{100 \times 6^2}{8} = 450 kNm$	1	
	Area of free BMD for AB 'a1' $= \frac{2}{3} \times 4 \times 120 = 320 kNm^2$	1	
	IIly centroidal distance from A, 'x1' $= \frac{1}{2} \times 4 = 2 m$		
	IIrly area of free BMD for BC 'a2' $= 2/3 \times 6 \times 450$ $= 1800 kN \cdot m^2$	1	
	and centroid distance from B 'x2' $= 6/2 = 3 m$		
	Let M_A, M_B & M_C be the support moment at A, B, C applying clapeyron's theorem $M_A L_1 + 2M_B(L_1+L_2) + M_C L_2 = \frac{6 a_1 x_1}{L_1} + \frac{6 a_2 x_2}{L_2}$	1	

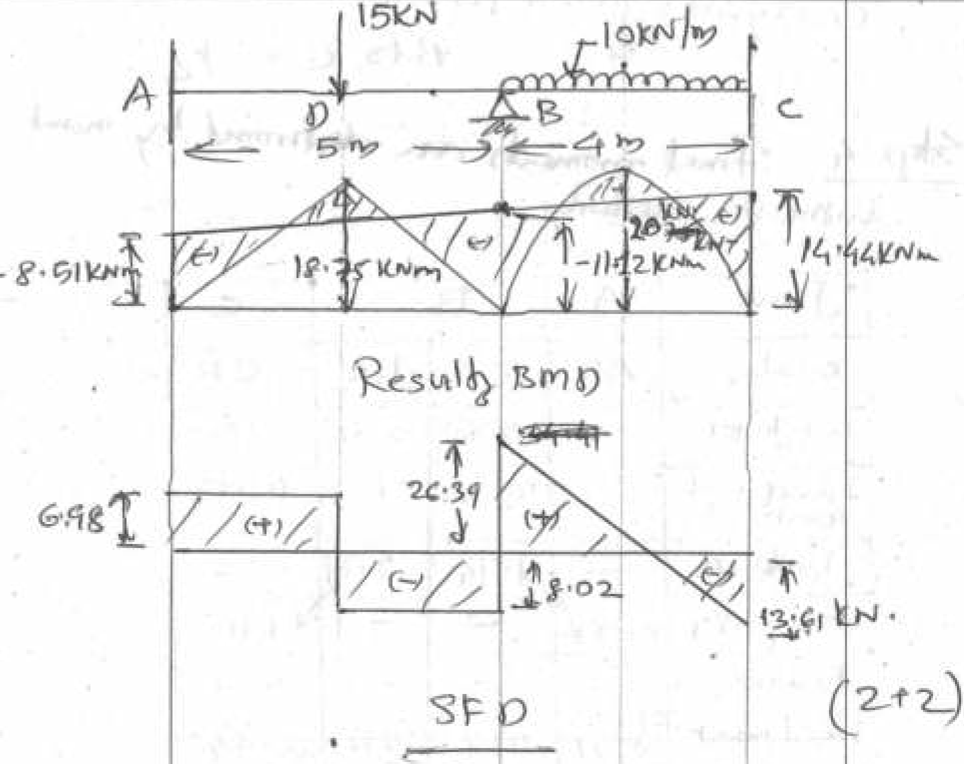
Code : Version:

Qn. No.	Scoring Indicators	Split score	Total score
	$M_A = M_B = 0$ (Simply supported).		
	$\therefore 2M_B(4+6) = \frac{6 \times 320 \times 2}{4} + \frac{6 \times 1800 \times 3}{6}$		
	$\therefore M_B = \underline{318 \text{ KNm}}$. →	2	
	Reactions: R_A, R_B & R_C be the reactions at A, B & C		
	BM at $B = -318 = R_A \times 4 - \frac{60 \times 4^2}{2}$ →	2	
	$\therefore R_A = \underline{40.50 \text{ KN}}$		
	IIIly for ~~318~~ span BC		
	$-318 = R_C \times 6 - \frac{100 \times 6^2}{2}$ →	2	
	$\therefore R_C = \underline{247 \text{ KN}}$		
	$\therefore R_B = (60 \times 4) + (100 \times 6) - 40.50 - 247$ →	1	15.
	$= \underline{552.50 \text{ KN}}$		
	knowing the values of R_A, R_B & R_C → SF diagram can be drawn		
	knowing the values of M_A, M_B & M_C → fixed BM can be drawn overlapping the free BMD.		
	OR		
X	Given:		
	span AB $l_1 = 5$ m		
	" BC $l_2 = 4$ m		
	for span AB 'W' = 15 KN		
	" BC $w = 10$ KN/m.		

Scoring Indicators

Code : **Version:**

Qn. No.	Scoring Indicators	Split score	Total score



(2+2)

Step I for span AB

Fixing moment at A $= \frac{(-)WL_1}{8} = \frac{(-)15\times5}{8} = (-)9.38$ KNm.

" B $= +\frac{WL_1}{8} = +9.38$ KNm

For span BC

Fixing moment at B $= \frac{-wL_2^2}{12} = \frac{-10\times4^2}{12} = (-)13.33$ KNm

" at C $= \frac{+wL_2^2}{12} = +13.33$ KNm. — 2

Step-2 distribution factors at B

Stiffness factor for BA $= \frac{4EI}{L_1} = \frac{4EI}{5} = 0.80EI$

" BC $= \frac{4EI}{L_2} = \frac{4EI}{4} = EI$

∴ distribution factor for BA $= \frac{0.80EI}{0.80EI+EI} = 0.44$

∴ " for BC $= \frac{EI}{EI+0.80EI} = 0.56$ — 2

Code : Version:

Qn. No.	Scoring Indicators	Split score	Total score
	Step. 3 Carry over factor from B to A = 1/2		
	" B to C = 1/2	1	
	Step-4 Final moments are determined by moment distribution method		

Joint	A	B		C
Member	AB	BA	BC	CB
Dist. factor	0	0.44	0.56	0
Fixed end moment	-9.38	+9.38	-13.33	+13.33
balance	—	1.74	2.21	—
Carry over	0.87	—	—	1.11
Balance	—	—	—	—
Final moment	(-)8.51	11.12	-11.12	14.44

→ 2

Step-5 $M_A = -8.51\,KNm$, $M_B = (-)11.12$, $M_C = 14.44$

Free BM for span AB $= \frac{WL_1}{4} = \frac{15 \times 5}{4} = 18.75\,KNm$

" $BC = \frac{wL_2^2}{8} = \frac{10 \times 4^2}{8} = 20\,KNm$

Resultant BMD can be drawn by using free BMD & M_A, M_B & M_C → 2

Step-6 R_A, R_B, R_C be the reactions at A, B, C

BM at B $= -11.12$

$\therefore -11.12 = -8.51 + R_A \times 5 - 15 \times 2.50$

$\therefore R_A = 6.98\,KN$

IIIly for span BC

BM at B $=$ ~~8.51~~ -11.12

Scoring Indicators

Code : **Version:**

Qn. No.	Scoring Indicators	Split score	Total score
	$\therefore -11.12 = 14.44 + R_C \times 4 - \frac{10 \times 4^2}{2}$ $\therefore R_C = 13.61$ $\therefore R_A = R_B = \cancel{(15\times} \; 15 + (10 \times 4) - 6.98 - 13.61$ $= \underline{34.41 \text{ KN}}$ → 2 Knowing the values of R_A, R_B, R_C the SFD can be drawn	2	15