UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2021/2022

COURSE NAME	:	ADVANCED STRUCTURAL ANALYSIS
COURSE CODE	:	BFS 40103
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JANUARY / FEBRUARY 2022
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS. 2. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **CLOSE BOOK**.

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

Q1 (a) Explain **THREE (3)** fundamental conditions for plastic analysis.

(3 marks)

(b) A rigid frame structure that is subjected with a vertical load 2P at point E and a horizontal load P at point B is shown in **FIGURE Q1**. Solve the following problems.

(i) Identify the failure modes available for the structure.

(6 marks)

(ii) Determine the load required to cause collapse of the structure for each mode.

(14 marks)

(iii) Compare and determine the highest collapse load Pu for the frame.

(2 marks)

Q2 A rigid jointed steel frame ABC carries a concentrated load W at point B as shown in **FIGURE Q2**. The given data are h_1=4.2m, h_2=4.2m v=4.0m, I_{AB}=1280cm^4 and I_{BC}=1050cm^4. Determine the following:

(a) Formulate the instability equation.

(17 marks)

(b) Investigate the critical load for the frame.

(4 marks)

(c) Calculate and check the stress and safety factor.

(4 marks)

Q3 In mathematical and analytical field, super positioning method is often used to ease the derivation of equations. Same goes to structural analysis, this process was done by Castagliano, Timoshenko, Euler etc. to the realization of structural equations we are using today. Based on the Free Body Diagram (FBD) shown in **FIGURE Q3**, the beam is applied with an Axial Load N kN and Edge Moments M_A kNm and M_B kNm. The length of the beam is L m and the Bending Stiffness EI is constant. Answer the followings.

(a) Describe and illustrate all possible combinations of the principle of superposition involved to form the configuration shown in **FIGURE Q3**.

(6 marks)

(b) Using your technical knowledge, derive all the combinations that you describe in Q3(a).

(30 marks)

(c) Examine and compare the results obtained from your derivation in Q3(b).

(6 marks)

(d) Generate the stiffness matrix from the result obtained in Q3(c).

(6 marks)

(e) Describe **TWO (2)** other cases that apply this principle in civil engineering.

(2 marks)

– END OF QUESTIONS –

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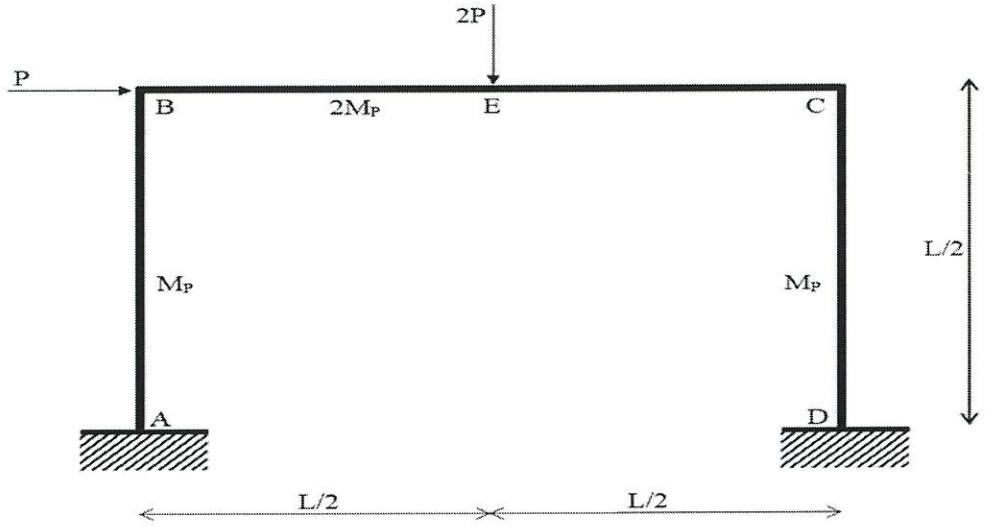

FIGURE Q1

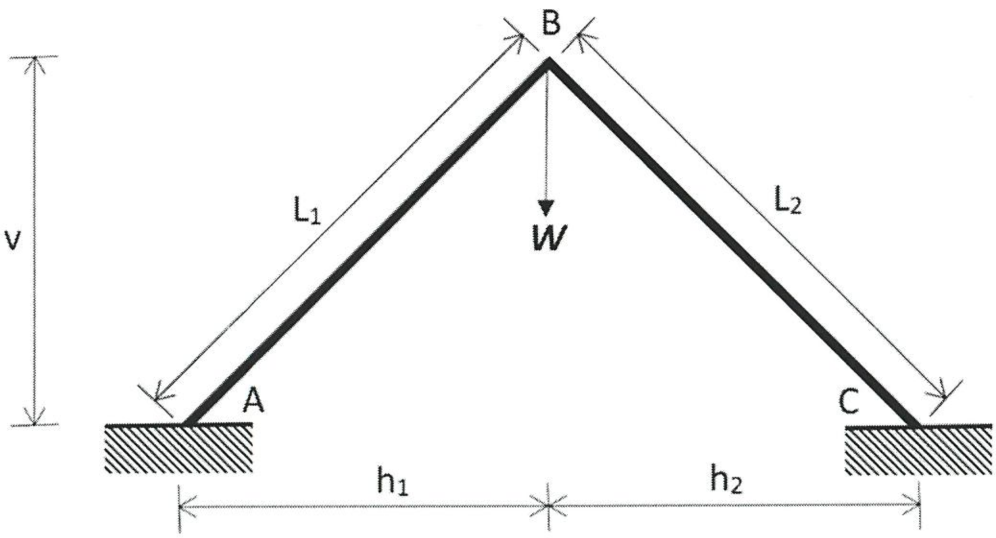

FIGURE Q2

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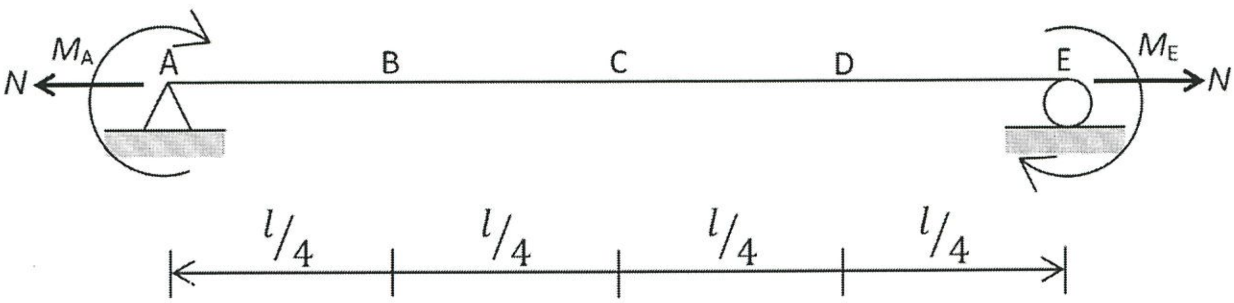

FIGURE Q3

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FORMULA

$$\frac{d^4w}{dx^4} + 2\frac{d^4w}{dx^2dy^2} + \frac{d^4w}{dy^4} = \frac{q}{D}$$

$$\frac{d}{dr}\left[\frac{1}{r}\frac{d}{dr}\left(r\frac{dw}{dr}\right)\right] += \frac{Q}{D}$$

$$M_x = -\frac{Eh^3}{12(1-v^2)}\left[\frac{d^2w}{dx^2} + v\frac{d^2w}{dy^2}\right]$$

$$M_r = -\frac{Eh^3}{12(1-v^2)}\left[\frac{d^2w}{dr^2} + \frac{v}{r}\frac{dw}{dr}\right]$$

$$M_y = -\frac{Eh^3}{12(1-v^2)}\left[\frac{d^2w}{dy^2} + v\frac{d^2w}{dx^2}\right]$$

$$M_t = -\frac{Eh^3}{12(1-v^2)}\left[\frac{1}{r}\frac{dw}{dr} + v\frac{d^2w}{dr^2}\right]$$

$$\int r\log r = \frac{r^2}{2}\left(\log r - \frac{1}{2}\right)$$

$$k = \frac{EA}{L}\begin{bmatrix} \alpha^2 & \alpha\beta & -\alpha^2 & -\alpha\beta \\ \alpha\beta & \beta^2 & -\alpha\beta & -\beta^2 \\ -\alpha^2 & -\alpha\beta & \alpha^2 & \alpha\beta \\ -\alpha\beta & -\beta^2 & \alpha\beta & \beta^2 \end{bmatrix}$$

$$c = \frac{\sin 2\alpha - 2\alpha}{2\alpha\cos 2\alpha - \sin 2\alpha}$$

$$s = \frac{\alpha(1 - 2\alpha\cot 2\alpha)}{\tan\alpha - \alpha}$$

$$P_i = \frac{W}{\left(\frac{v}{L_i}\right) + \left(\frac{h_i v}{L_i h_j}\right)}$$

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TABLE 1 : Tabulated selected values of stability functions (compression)

ρ	s	c	$s(1-c^2)$	$(sc)^2$
0.000	4.000	0.500	3.000	4.000
0.040	3.947	0.510	2.920	4.052
0.080	3.894	0.521	2.837	4.116
0.120	3.840	0.532	2.753	4.173
0.160	3.785	0.543	2.669	4.224
0.200	3.730	0.555	2.581	4.286
0.240	3.674	0.568	2.489	4.355
0.280	3.617	0.581	2.396	4.416
0.320	3.560	0.595	2.300	4.487
0.360	3.502	0.609	2.203	4.548
0.400	3.444	0.624	2.103	4.618
0.440	3.385	0.640	1.999	4.693
0.480	3.325	0.657	1.890	4.772
0.520	3.264	0.675	1.777	4.854
0.560	3.203	0.694	1.660	4.941
0.600	3.140	0.714	1.539	5.026
0.640	3.077	0.735	1.415	5.115
0.680	3.013	0.757	1.286	5.202
0.720	2.948	0.781	1.150	5.301
0.760	2.883	0.806	1.010	5.400
0.800	2.816	0.833	0.862	5.502
0.840	2.748	0.862	0.706	5.611
0.880	2.680	0.893	0.543	5.728
0.920	2.610	0.926	0.372	5.841
0.960	2.539	0.962	0.189	5.966
1.000	2.467	1.000	0.000	6.086
1.040	2.394	1.042	-0.205	6.223
1.080	2.320	1.087	-0.421	6.360
1.120	2.245	1.136	-0.652	6.504
1.160	2.168	1.190	-0.902	6.656
1.200	2.090	1.249	-1.170	6.814
1.240	2.011	1.314	-1.461	6.983
1.280	1.930	1.386	-1.778	7.156
1.320	1.848	1.465	-2.118	7.330
1.360	1.764	1.555	-2.501	7.524
1.400	1.678	1.656	-2.924	7.722
1.440	1.591	1.770	-3.393	7.930
1.480	1.502	1.900	-3.920	8.144
1.520	1.411	2.051	-4.525	8.375
1.560	1.319	2.227	-5.223	8.628
1.600	1.224	2.435	-6.033	8.883
1.640	1.127	2.684	-6.992	9.150
1.680	1.028	2.988	-8.150	9.435
1.720	0.927	3.367	-9.582	9.742
1.760	0.823	3.852	-11.389	10.050
1.800	0.717	4.497	-13.783	10.396
1.840	0.608	5.393	-17.075	10.751
1.880	0.496	6.722	-21.916	11.116
1.920	0.382	8.899	-29.869	11.556
1.960	0.264	13.109	-45.103	11.977

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TABLE 2 : Tabulated selected values of stability functions (compression)table

ρ	s	c	$s(1-c^2)$	$(sc)^2$
2.000	0.143	24.684	-86.987	12.460
2.040	0.018	197.386	-701.284	12.623
2.080	-0.110	-33.292	121.809	13.411
2.120	-0.242	-15.436	57.419	13.954
2.160	-0.379	-10.085	38.168	14.609
2.200	-0.519	-7.511	28.760	15.196
2.240	-0.665	-5.998	23.259	15.909
2.280	-0.815	-5.003	19.584	16.626
2.320	-0.971	-4.299	16.974	17.425
2.360	-1.133	-3.775	15.013	18.293
2.400	-1.301	-3.370	13.474	19.223
2.440	-1.475	-3.048	12.228	20.212
2.480	-1.656	-2.787	11.207	21.301
2.520	-1.845	-2.570	10.341	22.483
2.560	-2.043	-2.387	9.598	23.782
2.600	-2.249	-2.231	8.945	25.175
2.640	-2.465	-2.097	8.375	26.720
2.680	-2.692	-1.981	7.872	28.439
2.720	-2.930	-1.878	7.404	30.278
2.760	-3.180	-1.788	6.986	32.329
2.800	-3.445	-1.708	6.605	34.622
2.840	-3.725	-1.637	6.257	37.183
2.880	-4.021	-1.573	5.928	40.006
2.920	-4.337	-1.515	5.617	43.172
2.960	-4.673	-1.463	5.329	46.739

TABLE 3 : Tabulated selected values of stability functions (tension)table

ρ	s	c	$s(1-c^2)$	$(sc)^2$
0.000	4.000	0.500	3.000	4.000
-0.200	4.257	0.455	3.376	3.752
-0.400	4.501	0.418	3.715	3.540
-0.600	4.735	0.387	4.026	3.358
-0.800	4.959	0.361	4.313	3.205
-1.000	5.175	0.338	4.584	3.060
-1.200	5.382	0.318	4.838	2.929
-1.400	5.583	0.301	5.077	2.824
-1.600	5.777	0.286	5.304	2.730
-1.800	5.965	0.272	5.524	2.632
-2.000	6.147	0.260	5.731	2.554
-2.200	6.324	0.249	5.932	2.480
-2.400	6.496	0.239	6.125	2.410
-2.600	6.664	0.230	6.311	2.349
-2.800	6.828	0.222	6.491	2.298
-3.000	6.988	0.215	6.665	2.257
-3.200	7.144	0.208	6.835	2.208
-3.400	7.297	0.201	7.002	2.151
-3.600	7.446	0.195	7.163	2.108
-3.800	7.593	0.190	7.319	2.081

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TABLE 4 : Fixed End Moments

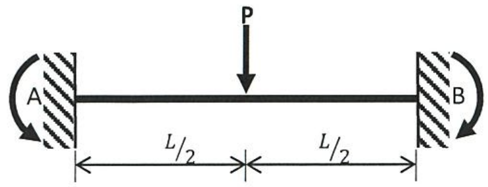
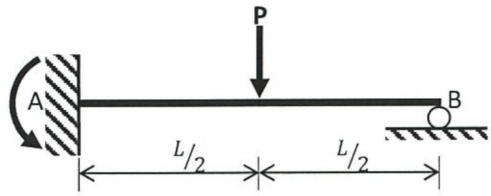
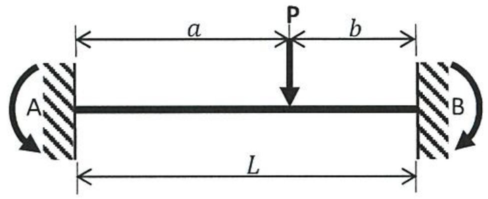
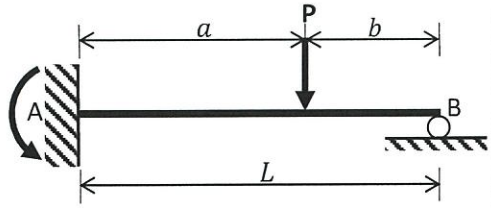
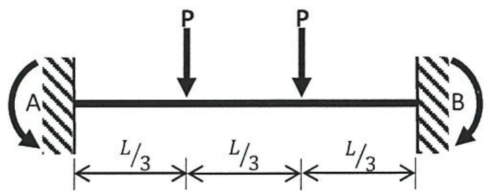
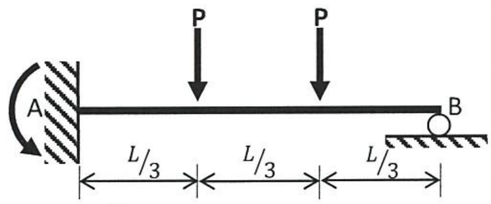
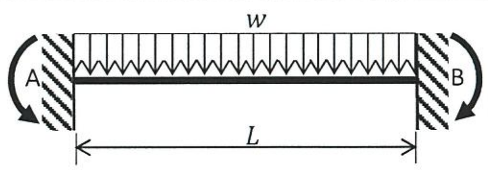
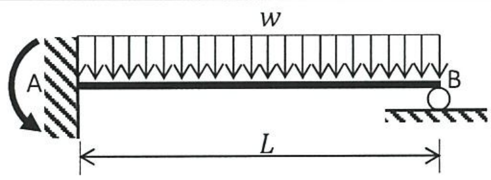
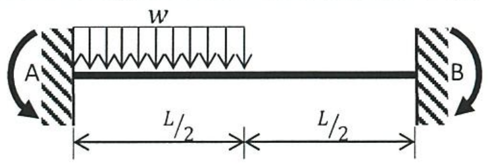
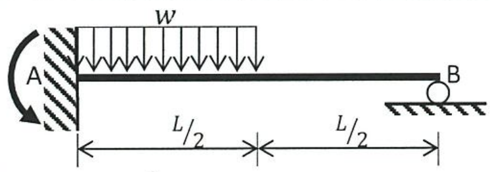
 $FEM_{AB} = \frac{PL}{8}$ $FEM_{BA} = \frac{PL}{8}$	 $FEM_{AB} = \frac{3PL}{16}$
 $FEM_{AB} = \frac{Pb^2a}{L^2}$ $FEM_{BA} = \frac{Pa^2b}{L^2}$	 $FEM_{AB} = \left(\frac{P}{L^2}\right)\left(b^2a + \frac{a^2b}{2}\right)$
 $FEM_{AB} = \frac{2PL}{9}$ $FEM_{BA} = \frac{2PL}{9}$	 $FEM_{AB} = \frac{PL}{3}$
 $FEM_{AB} = \frac{wL^2}{12}$ $FEM_{BA} = \frac{wL^2}{12}$	 $FEM_{AB} = \frac{wL^2}{8}$
 $FEM_{AB} = \frac{11wL^2}{192}$ $FEM_{BA} = \frac{5wL^2}{192}$	 $FEM_{AB} = \frac{9wL^2}{128}$

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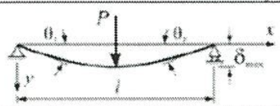
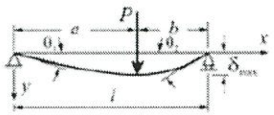
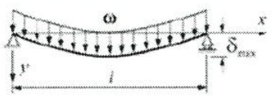
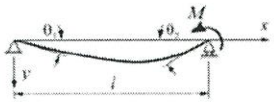
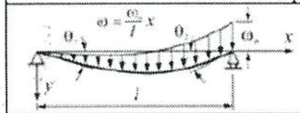
TABLE 5 : Slope and deflection of beam

BEAM TYPE	SLOPE AT ENDS	DEFLECTION AT ANY SECTION IN TERMS OF x	MAXIMUM AND CENTER DEFLECTION
6. Beam Simply Supported at Ends – Concentrated load P at the center			
	$\theta_1 = \theta_2 = \frac{Pl^2}{16EI}$	$y = \frac{Px}{12EI}\left(\frac{3l^2}{4} - x^2\right)$ for $0 < x < \frac{l}{2}$	$\delta_{max} = \frac{Pl^3}{48EI}$
7. Beam Simply Supported at Ends – Concentrated load P at any point			
	$\theta_1 = \frac{Pb(l^2 - b^2)}{6lEI}$ $\theta_2 = \frac{Pab(2l - b)}{6lEI}$	$y = \frac{Pbx}{6lEI}(l^2 - x^2 - b^2)$ for $0 < x < a$ $y = \frac{Pb}{6lEI}\left[\frac{l}{b}(x-a)^3 + (l^2 - b^2)x - x^3\right]$ for $a < x < l$	$\delta_{max} = \frac{Pb(l^2 - b^2)^{3/2}}{9\sqrt{3}lEI}$ at $x = \sqrt{(l^2 - b^2)/3}$ $\delta = \frac{Pb}{48EI}(3l^2 - 4b^2)$ at the center, if $a > b$
8. Beam Simply Supported at Ends – Uniformly distributed load ω (N/m)			
	$\theta_1 = \theta_2 = \frac{\omega l^3}{24EI}$	$y = \frac{\omega x}{24EI}(l^3 - 2lx^2 + x^3)$	$\delta_{max} = \frac{5\omega l^4}{384EI}$
9. Beam Simply Supported at Ends – Couple moment M at the right end			
	$\theta_1 = \frac{Ml}{6EI}$ $\theta_2 = \frac{Ml}{3EI}$	$y = \frac{Mlx}{6EI}\left(1 - \frac{x^2}{l^2}\right)$	$\delta_{max} = \frac{Ml^2}{9\sqrt{3}\,EI}$ at $x = \frac{l}{\sqrt{3}}$ $\delta = \frac{Ml^2}{16EI}$ at the center
10. Beam Simply Supported at Ends – Uniformly varying load: Maximum intensity ω_o (N/m)			
	$\theta_1 = \frac{7\omega_o l^3}{360EI}$ $\theta_2 = \frac{\omega_o l^3}{45EI}$	$y = \frac{\omega_o x}{360lEI}(7l^4 - 10l^2x^2 + 3x^4)$	$\delta_{max} = 0.00652\frac{\omega_o l^4}{EI}$ at $x = 0.519l$ $\delta = 0.00651\frac{\omega_o l^4}{EI}$ at the center