



UNIVERSITY COLLEGE TATI (UC TATI)

FINAL EXAMINATION QUESTION BOOKLET

COURSE CODE	: DTM 2023
COURSE	: SOLID MECHANICS
SEMESTER/SESSION	: 1– 2023/2024
DURATION	: 3 HOURS

Instructions:

1. This booklet contains **4** questions. Answer **ALL** questions.
2. All answers should be written in answer booklet.
3. Write and Sketch legibly wherever required.
4. Question booklet need to be returned after session ends.
5. If in doubt, raise your hand and ask the invigilator.

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO

THIS BOOKLET CONTAINS 11 PRINTED PAGES INCLUDING COVER PAGE

QUESTION 1

- a) Two gage marks are placed exactly 250 mm apart on a 12 mm diameter aluminum rod with $E = 73$ GPa and an ultimate strength of 140 MPa. Knowing that the distance between the gage marks is 250.28 mm after a load is applied,

Solve

- i. the stress in the rod (5 marks)
 - ii. the factor of safety. (3 marks)
- b) Strain gage located at C on the surface of bone AB indicates that the average normal stress in the bone is 3.80 MPa when the bone is subjected to two 1200 N forces as shown in Figure 1. Assuming the cross section of the bone at C to be annular and knowing that its outer diameter is 25 mm, **solve** the inner diameter of the bone's cross section at C. (8 marks)

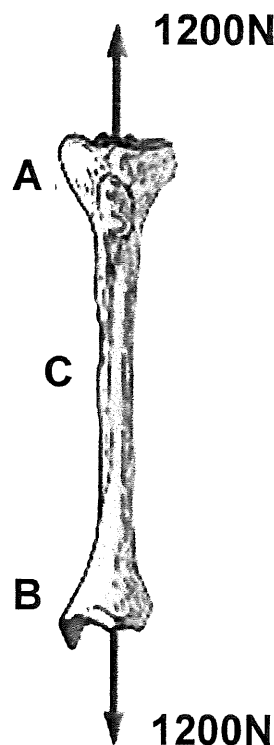


Figure 1

- c) **Figure 2** show a pipe CE, which has an outer diameter of 90 mm and a wall thickness of 6 mm, is made of an aluminum for which the allowable shearing stress is 54 MPa. The solid rod AB has a diameter $d_{AB} = 60$ mm and is made of a steel for which the allowable shearing stress is 85 MPa. **Compute** the smallest torque (T) that can be applied at A.

(12 marks)

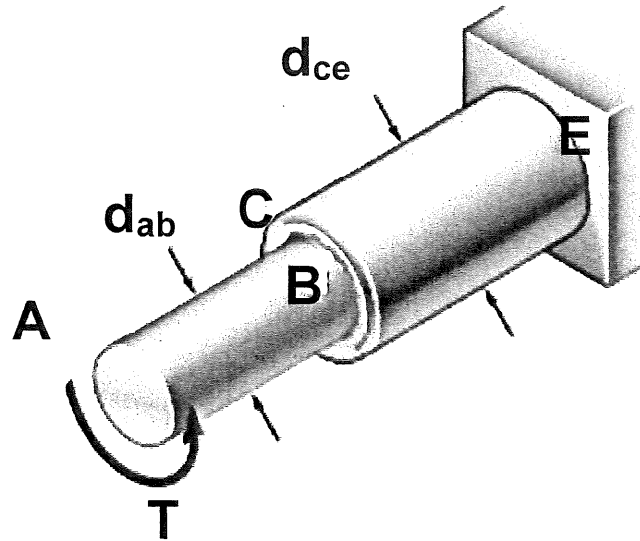


Figure 2

QUESTION 2

According to **Figure 3**, the beam is loaded with load at point A-B and C. The beam can afford the maximum stress of 160 MPa. You need to provide the following information:

- i. **Sketch** the free body diagram (2 marks)
- ii. **Compute** the reaction values at both supports. (2 marks)
- iii. **Construct** the shear force diagram for the beam (10 marks)
- iv. **Construct** the bending moment diagram for the beam (10 marks)
- v. **Determine** the minimum section modulus (S) (3 marks)
- vi. **Identify** the most economical W-shapes beam to support the load (3 marks)

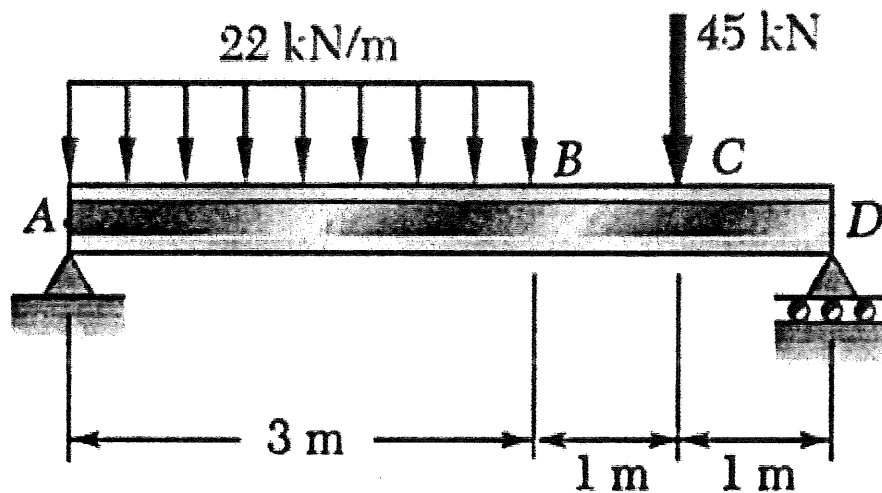
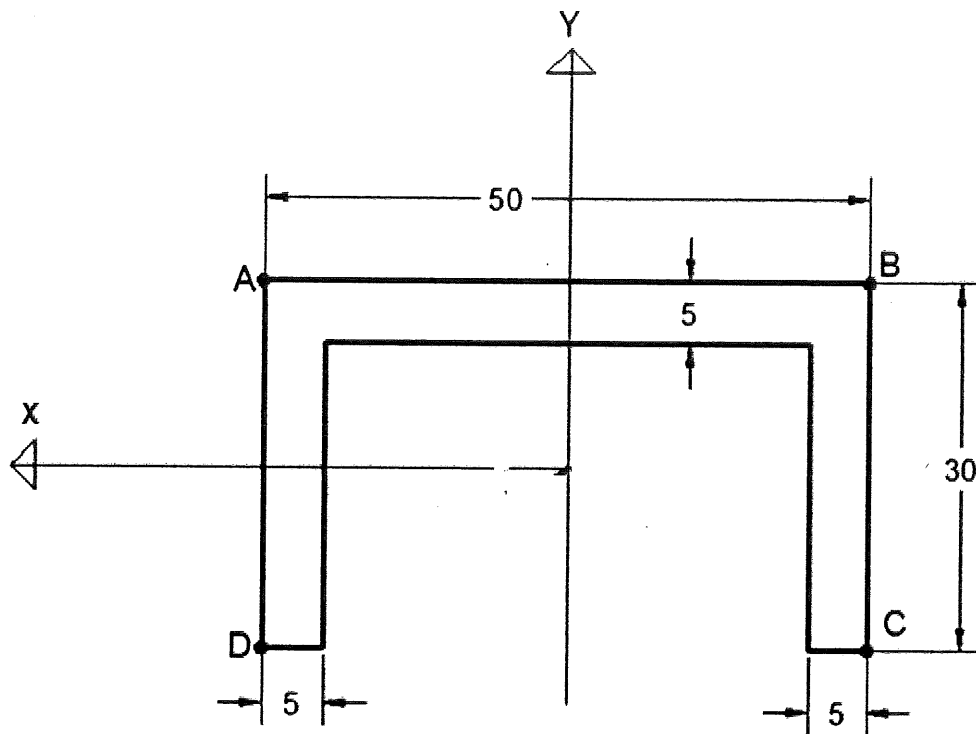


Figure 3

QUESTION 3

In Figure , show a cross sectional of "C" beam. **Compute** the Moment of Inertia (I_{xx}) of the shape (10 marks)



All dimension in mm

Figure 4

QUESTION 4

Figure shows the timber beam with two (2) loading force. The elastic modulus of the beam is $E=12 \text{ GPa}$. You need to:

- i. **Sketch** the free body diagram (2 marks)
- ii. **Compute** the reaction values at both supports. (2 marks)
- iii. **Compute** the moment of inertia (2 marks)
- iv. **Compute** the constant value (C&D) (14 marks)
- v. **Show** the slope equation of the beam (3 marks)
- vi. **Show** the deflection equation of the beam (3 marks)
- vii. **Compute** the slope at end A (3 marks)
- viii. **Compute** the deflection at the midpoint C (3 marks)

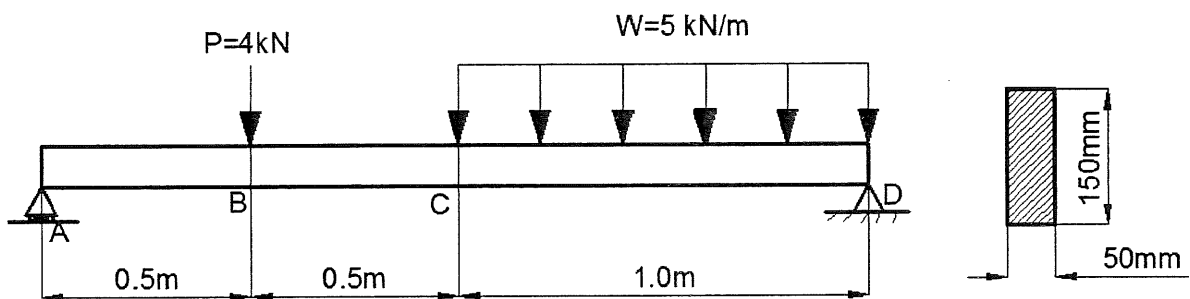


Figure 5

-----End of question-----

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Criteria	Marks
All questions answered will be marked according to answer scheme	/ 100



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LIST OF FORMULA AND STEEL TABLE

SOLID MECHANICS

BME 2023/DTM 2023

FORMULA
Stress Strain

Normal stress

$$\sigma = \frac{F}{A}$$

Shear stress

$$\tau = \frac{F}{A}$$

double shear

$$\tau = \frac{F}{2A}$$

Modulus of Elasticity

$$E = \frac{FL}{Ax}$$

Torsion

$$\frac{T}{J} = \frac{G\theta}{L} = \frac{\tau}{R}$$

Polar second moment of area

$$J_{solid\ shaft} = \frac{\pi D^2}{32} \quad J_{hollow\ shaft} = \frac{\pi D^2}{32} - \frac{\pi d^2}{32}$$

Shear Force and Bending Moment

Minimum section Modulus

$$S_{min} = \frac{|M|_{max}}{\sigma_{allowable}}$$

Interpolation

$$Vb - Va = -wx$$

Bending stress

$$\bar{Y} = \frac{\sum \bar{y} A}{\sum A}$$

Parallel theorem

$$I_{xx} = I_{xx} + Ad^2$$

Shear stress in Beam

$$\tau_1 = \frac{F \cdot A \cdot \bar{y}}{I b_1}$$

$$\tau_1 = \frac{F \cdot (A_1 y_1 + A_2 y_2)}{I b}$$

Non-Symmetrical Bending

$$\sigma = -\frac{M_z Y}{I_z} + \frac{M_y Z}{I_y}$$

Deflection of Beam

$$EI \frac{d^2 y}{dx^2} = M(x)$$

$$\text{Slope} = \frac{dy}{dx} = \theta(x)$$

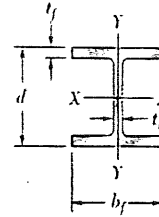
$$\text{deflection} = y(x)$$

ATTACHMENT 1

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Appendix C. Properties of Rolled-Steel Shapes
(SI Units)

W Shapes
(Wide-Flange Shapes)



Designation†	Area A, mm ²	Depth d, mm	Flange		Web Thick- ness t _w , mm	Axis X-X			Axis Y-Y		
			Width b _f , mm	Thick- ness t _f , mm		I _x 10 ⁶ mm ⁴	S _x 10 ³ mm ³	r _x mm	I _y 10 ⁶ mm ⁴	S _y 10 ³ mm ³	r _y mm
W920 × 446	57000	933	423	42.70	24.0	8470	18200	385	540	2550	97.3
201	25600	903	304	20.10	15.2	3250	7200	356	94.4	621	60.7
W840 × 299	38100	855	400	29.20	18.2	4790	11200	355	312	1560	90.5
176	22400	835	292	18.80	14.0	2460	5890	331	78.2	536	59.1
W760 × 257	32600	773	381	27.10	16.6	3420	8850	324	250	1310	87.6
147	18700	753	265	17.00	13.2	1660	4410	298	52.9	399	53.2
W690 × 217	27700	695	355	24.80	15.4	2340	6730	291	185	1040	81.7
125	16000	678	253	16.30	11.7	1190	3510	273	44.1	349	52.5
W610 × 155	19700	611	324	19.00	12.7	1290	4220	256	108	667	74.0
101	13000	603	228	14.90	10.5	764	2530	242	29.5	259	47.6
W530 × 150	19200	543	312	20.30	12.7	1010	3720	229	103	660	73.2
92	11800	533	209	15.60	10.2	552	2070	216	23.8	228	44.9
66	8370	525	165	11.40	8.9	351	1340	205	8.57	104	32.0
W460 × 158	20100	476	284	23.90	15.0	796	3340	199	91.4	644	67.4
113	14400	463	280	17.30	10.8	556	2400	196	63.3	452	66.3
74	9450	457	190	14.50	9.0	333	1460	188	16.6	175	41.9
52	6630	450	152	10.80	7.6	212	942	179	6.34	83.4	30.9
W410 × 114	14600	420	261	19.30	11.6	462	2200	178	57.2	438	62.6
85	10800	417	181	18.20	10.9	315	1510	171	18.0	199	40.8
60	7580	407	178	12.80	7.7	216	1060	169	12.1	136	40.0
46.1	5890	403	140	11.20	7.0	156	774	163	5.14	73.4	29.5
38.8	4990	399	140	8.80	6.4	127	637	160	4.04	57.7	28.5
W360 × 551	70100	455	418	67.60	42.0	2260	9930	180	825	3950	108
216	27600	375	394	27.70	17.3	712	3800	161	283	1440	101
122	15500	363	257	21.70	13.0	365	2010	153	61.5	479	63.0
101	12900	357	255	18.30	10.5	302	1690	153	50.6	397	62.6
79	10100	354	205	16.80	9.4	227	1280	150	24.2	236	48.9
64	8140	347	203	13.50	7.7	178	1030	148	18.9	186	48.2
57.8	7220	358	172	13.10	7.9	161	899	149	11.1	129	39.2
44	5730	352	171	9.80	6.9	122	693	146	8.18	95.7	37.8
39	4980	353	128	10.70	6.5	102.0	578	143	3.75	58.6	27.4
32.9	4170	349	127	8.50	5.8	82.7	474	141	2.91	45.8	26.4

†A wide-flange shape is designated by the letter W followed by the nominal depth in millimeters and the mass in kilograms per meter.

(Table continued on page 749)

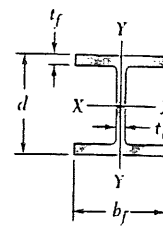
ATTACHMENT 2

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Appendix C. Properties of Rolled-Steel Shapes
(SI Units)

Continued from page 748

W Shapes
(Wide-Flange Shapes)



Designation†	Area A, mm ²	Depth d, mm	Flange		Web Thick- ness t _w , mm	Axis X-X			Axis Y-Y		
			Width b _f , mm	Thick- ness t _f , mm		I _x 10 ⁶ mm ⁴	S _x 10 ³ mm ³	r _x mm	I _y 10 ⁶ mm ⁴	S _y 10 ³ mm ³	r _y mm
W310 × 143	18200	323	309	22.9	14.0	348	2150	138	113	731	78.8
107	13600	311	306	17.0	10.9	248	1590	135	81.2	531	77.3
74	9480	310	205	16.3	9.4	165	1060	132	23.4	228	49.7
60	7590	303	203	13.1	7.5	129	851	130	18.3	180	49.1
52	6670	318	167	13.2	7.6	119	748	134	10.3	123	39.3
44.5	5690	313	166	11.2	6.6	99.2	634	132	8.55	103	38.8
38.7	4940	310	165	9.7	5.8	85.1	549	131	7.27	88.1	38.4
32.7	4180	313	102	10.8	6.6	65.0	415	125	1.92	37.6	21.4
23.8	3040	305	101	6.7	5.6	42.7	280	119	1.16	23.0	19.5
W250 × 167	21300	289	265	31.8	19.2	300	2080	119	98.8	746	68.1
101	12900	264	257	19.6	11.9	164	1240	113	55.5	432	65.6
80	10200	256	255	15.6	9.4	126	984	111	43.1	338	65.0
67	8580	257	204	15.7	8.9	104	809	110	22.2	218	51.0
58	7420	252	203	13.5	8.0	87.3	693	108	18.8	185	50.3
49.1	6250	247	202	11.0	7.4	70.6	572	106	15.1	150	49.2
44.8	5720	266	148	13.0	7.6	71.1	535	111	7.03	95.0	35.1
32.7	4180	258	146	9.1	6.1	48.9	379	108	4.73	64.8	33.7
28.4	3630	260	102	10.0	6.4	40.0	308	105	1.78	34.9	22.1
22.3	2850	254	102	6.9	5.8	28.9	228	101	1.23	24.1	20.8
W200 × 86	11000	222	209	20.6	13.0	94.7	853	92.4	31.4	300	53.2
71	9100	216	206	17.4	10.2	76.6	709	91.7	25.4	247	52.8
59	7560	210	205	14.2	9.1	61.1	582	89.9	20.4	199	51.9
52	6660	206	204	12.6	7.9	52.7	512	89.0	17.8	175	51.7
46.1	5860	203	203	11.0	7.2	45.5	448	87.9	15.3	151	51.1
41.7	5310	205	166	11.8	7.2	40.9	399	87.8	9.01	109	41.2
35.9	4580	201	165	10.2	6.2	34.4	342	86.7	7.64	92.6	40.8
31.3	4000	210	134	10.2	6.4	31.4	299	88.6	4.1	61.2	32.0
26.6	3390	207	133	8.4	5.8	25.8	249	87.2	3.3	49.6	31.2
22.5	2860	206	102	8.0	6.2	20.0	194	83.6	1.42	27.8	22.3
19.3	2480	203	102	6.5	5.8	16.6	164	81.8	1.15	22.5	21.5
W150 × 37.1	4730	162	154	11.6	8.1	22.2	274	68.5	7.07	91.8	38.7
29.8	3790	157	153	9.3	6.6	17.2	219	67.4	5.56	72.7	38.3
24.0	3060	160	102	10.3	6.6	13.4	168	66.2	1.83	35.9	24.5
18.0	2290	153	102	7.1	5.8	9.17	120	63.3	1.26	24.7	23.5
13.5	1730	150	100	5.5	4.3	6.87	91.6	63.0	0.918	18.4	23.0
W130 × 28.1	3580	131	128	10.9	6.9	10.9	166	55.2	3.81	59.5	32.6
23.8	3010	127	127	9.1	6.1	8.80	139	54.1	3.11	49.0	32.1
W100 × 19.3	2480	106	103	8.8	7.1	4.77	90.0	43.9	1.61	31.3	25.5

†A wide-flange shape is designated by the letter W followed by the nominal depth in millimeters and the mass in kilograms per meter.

