CE 120 – Spring 2020
Instructor: M.J. DeJong

CE 120 – Structural Engineering

Final Examination

** If you have any questions during the exam, I will be available by Zoom. Please logon to Zoom, ask your question, and then logoff. The Zoom Meeting ID is: **972 8290 6757**

Logistics (SAME AS SENT THROUGH bCOURSES):

- The exam will be available for download in the bCourses "Assignments" section under the "Final Exam" heading from 7pm CA time on Tuesday, May 12.
- Your exam must be uploaded by 10:15pm. I have included 15 extra minutes for upload, which should be plenty of time. You should stop working and start the upload process by 10pm.
- (NOTE: If you have pre-approved extra time, you have until 11:45pm to upload your exam. You should stop working and start the upload process by 11:30pm)
- Please logon to zoom to tell me if you have difficulty submitting the exam. You should tell me of any difficulties before 10:15pm.

Instructions (SAME AS SENT THROUGH bCOURSES):

- The exam is open book (i.e. reader) and open notes (including HW solutions). You are not permitted to use any other materials.
- You may use a calculator and watch, but no other electronic devices are permitted. (Note: you may use a tablet to write your solution).
- You are not permitted to communicate with any other people during the exam.
- You are not permitted to share the exam or your solution with anyone (either during or after your exam).
- Do all problems. Show all relevant work.
- You may write your solutions on the exam directly, immediately following the problem statements. Or you may use your own paper, but please clearly write the problem number at the top of each page, and use a new piece of paper for each problem.
- Please make sure to upload the pages in the correct order.
- Organize and write solutions neatly. Points may be taken off for messy solutions.
- Indicate units in final solutions. Points will be taken off if units are missing or signs are unclear.

****IMPORTANT:**
By submitting your exam, you are agreeing to the following Honor Pledge:

"I have neither given nor received aid during this examination. I will not share my exam solution with any other students in this class. I did not use any unapproved notes or electronic devices during the examination."

Signature: Han Liu.

Point Breakdown	
Problem 1:	30 points
Problem 2:	30 points
Problem 3:	15 points
Problem 4:	25 points
TOTAL:	100 points

CE 120 – Spring 2020
Final Exam

Some expressions

U = 1.4D
U = 1.2D + 1.6L
U = 1.2D + 1.0L + E
U = 0.9D + E

$$V_n = V_c + V_s$$

$$V_c = 2\sqrt{f_c'}bd$$

$$V_s = \frac{A_v f_y d}{s}$$

$$f_b \leq C_F \times C_f \times LDF \times F_b$$

$$f_v \leq LDF \times F_v$$

$$f_{c\perp} \leq LDF \times F_{c\perp}$$

$$f_b = \frac{M}{S}$$

$$f_v = \frac{VQ}{Ib} = 1.5\frac{V}{A}$$

$$f_{c\perp} = \frac{R}{A_b}$$

$$M_n = ZF_y$$

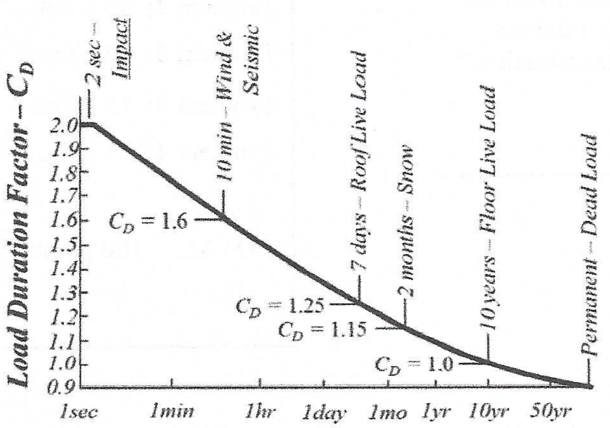
$$V_n = 0.6F_y td$$

simply supported beam under distributed load: $\delta = \frac{5}{384}\frac{wl^4}{EI}$

simply supported beam under concentrated load at mid-span : $\delta = \frac{1}{48}\frac{Pl^3}{EI}$

Construction	L	S	$KD+L$
Roof members:			
Supporting plaster ceiling	$l/360$	$l/360$	$l/240$
Supporting non-plaster ceiling	$l/240$	$l/240$	$l/180$
Not supporting ceiling	$l/180$	$l/180$	$l/120$
Floor members	$l/360$	–	$l/240$

Species and Commercial Grade	Allowable Unit Stresses in psi: Extreme Fiber in Bending, F_b: Single-member Uses	Extreme Fiber in Bending, F_b: Repetitive-member Uses*	Tension Parallel to Grain, F_t	Horizontal Shear Stress, F_v	Compression Perpendicular to Grain, $F_{c\perp}$	Compression Parallel to Grain, F_c	Modulus of Elasticity, E
Douglas Fir – Larch (North)							
Dense Select Structural	2100	2400	1400	95	730	1650	1,900,000



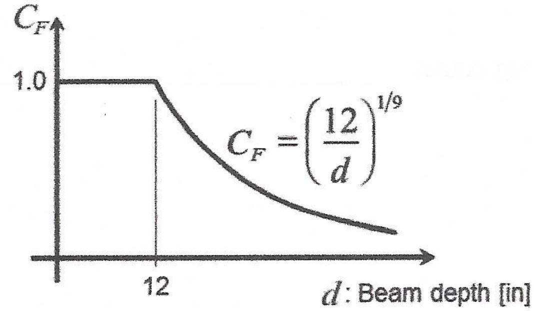
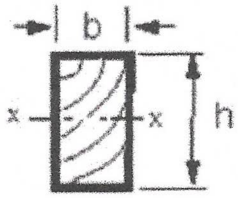
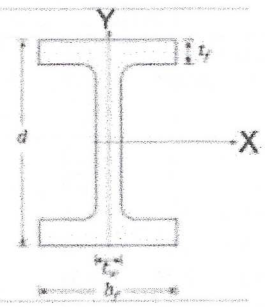


Table 13.2 Section properties of dimensional lumber

Nominal $b \times h$, inches	Surfaced Size, $b \times h$, inches	Area $A = bh$, in.^{2}	Section Modulus, $S = \frac{bh^2}{6}$, in.^{3}	Moment of Inertia, $I = \frac{bh^3}{12}$, in.^{4}	Board Feet per Lineal Foot of Piece
2 × 2	1.5 × 1.5	2.25	0.562	0.422	0.33
2 × 3	1.5 × 2.5	3.75	1.56	1.95	0.50
2 × 4	1.5 × 3.5	5.25	3.06	5.36	0.67
2 × 6	1.5 × 5.5	8.25	7.56	20.80	1.00
2 × 8	1.5 × 7.25	10.88	13.14	47.63	1.33
2 × 10	1.5 × 9.25	13.88	21.39	98.93	1.67
2 × 12	1.5 × 11.25	16.88	31.64	177.98	2.00
2 × 14	1.5 × 13.25	19.88	43.89	290.78	2.33
3 × 3	2.5 × 2.5	6.25	2.60	3.26	0.75
3 × 4	2.5 × 3.5	8.75	5.10	8.93	1.00
3 × 6	2.5 × 5.5	13.75	12.60	34.66	1.50
3 × 8	2.5 × 7.25	18.12	21.90	79.39	2.00
3 × 10	2.5 × 9.25	23.12	35.65	164.89	2.50
3 × 12	2.5 × 11.25	28.12	52.73	296.63	3.00
3 × 14	2.5 × 13.25	33.12	73.15	484.63	3.50
3 × 16	2.5 × 15.25	38.12	96.90	738.87	4.00
4 × 4	3.5 × 3.5	12.25	7.15	12.51	1.33
4 × 6	3.5 × 5.5	19.25	17.65	48.53	2.00
4 × 8	3.5 × 7.25	25.38	30.66	111.15	2.67
4 × 10	3.5 × 9.25	32.38	49.91	230.84	3.33
4 × 12	3.5 × 11.25	39.38	73.83	415.28	4.00
4 × 14	3.5 × 13.25	46.38	102.41	678.48	4.67
4 × 16	3.5 × 15.25	53.38	135.66	1034.42	5.33
6 × 6	5.5 × 5.5	30.25	27.73	76.26	3.00
6 × 8	5.5 × 7.5	41.25	51.56	193.36	4.00
6 × 10	5.5 × 9.5	52.25	82.73	392.96	5.00
6 × 12	5.5 × 11.5	63.25	121.23	697.07	6.00
6 × 14	5.5 × 13.5	74.25	167.06	1127.67	7.00
6 × 16	5.5 × 15.5	85.25	220.23	1706.78	8.00
6 × 18	5.5 × 17.5	96.25	280.73	2456.38	9.00
6 × 20	5.5 × 19.5	107.25	348.56	3398.48	10.00
8 × 8	7.5 × 7.5	56.25	70.31	263.67	5.33
8 × 10	7.5 × 9.5	71.25	112.81	535.86	6.67
8 × 12	7.5 × 11.5	86.25	165.31	950.55	8.00
8 × 14	7.5 × 13.5	101.25	227.81	1537.73	9.33
8 × 16	7.5 × 15.5	116.25	300.31	2327.42	10.67
8 × 18	7.5 × 17.5	131.25	382.81	3349.61	12.00
8 × 20	7.5 × 19.5	146.25	475.31	4634.30	13.33
8 × 22	7.5 × 21.5	161.25	577.81	6211.48	14.67
8 × 24	7.5 × 23.5	176.25	690.31	8111.17	16.00
10 × 10	9.5 × 9.5	90.25	142.90	678.76	8.33
10 × 12	9.5 × 11.5	109.25	209.40	1204.03	10.00
10 × 14	9.5 × 13.5	128.25	288.56	1947.80	11.67
10 × 16	9.5 × 15.5	147.25	380.40	2948.07	13.33
10 × 18	9.5 × 17.5	166.25	484.90	4242.84	15.00
10 × 20	9.5 × 19.5	185.25	602.06	5870.11	16.67
10 × 22	9.5 × 21.5	204.25	731.90	7867.88	18.33



W Shapes – Properties for designing

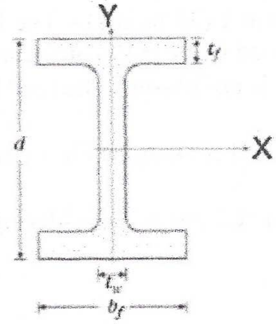


W = weight in plf
A = area, in.^{2}
I in moment of inertia, in.^{4}
Z = plastic modulus, in.^{3}
S = section modulus, in.^{3}
r = radius of gyration, in.
J = torsional constant, in.^{3}
All other dimensions in inches.

AISC_Manual_Label	W	A	d	b_f	t_w	t_f	I_x	Z_x	S_x	r_x	I_y	Z_y	S_y	r_y	J
W21X83	83.0	24.4	21.4	8.36	0.515	0.835	1830	196	171	8.67	81.4	30.5	19.5	1.83	4.34
W21X73	73.0	21.5	21.2	8.30	0.455	0.740	1600	172	151	8.64	70.6	26.6	17.0	1.81	3.02
W21X68	68.0	20.0	21.1	8.27	0.430	0.685	1480	160	140	8.60	64.7	24.4	15.7	1.80	2.45
W21X62	62.0	18.3	21.0	8.24	0.400	0.615	1330	144	127	8.54	57.5	21.7	14.0	1.77	1.83
W21X55	55.0	16.2	20.8	8.22	0.375	0.522	1140	126	110	8.40	48.4	18.4	11.8	1.73	1.24
W21X48	48.0	14.1	20.6	8.14	0.350	0.430	959	107	93.0	8.24	38.7	14.9	9.52	1.66	0.803
W21X57	57.0	16.7	21.1	6.56	0.405	0.650	1170	129	111	8.36	30.6	14.8	9.35	1.35	1.77
W21X50	50.0	14.7	20.8	6.53	0.380	0.535	984	110	94.5	8.18	24.9	12.2	7.64	1.30	1.14
W21X44	44.0	13.0	20.7	6.50	0.350	0.450	843	95.4	81.6	8.06	20.7	10.2	6.37	1.26	0.770
W18X119	119	35.1	19.0	11.3	0.655	1.06	2190	262	231	7.90	253	69.1	44.9	2.69	10.6
W18X106	106	31.1	18.7	11.2	0.590	0.940	1910	230	204	7.84	220	60.5	39.4	2.66	7.48
W18X97	97.0	28.5	18.6	11.1	0.535	0.870	1750	211	188	7.82	201	55.3	36.1	2.65	5.86
W18X86	86.0	25.3	18.4	11.1	0.480	0.770	1530	186	166	7.77	175	48.4	31.6	2.63	4.10
W18X76	76.0	22.3	18.2	11.0	0.425	0.680	1330	163	146	7.73	152	42.2	27.6	2.61	2.83
W18X71	71.0	20.9	18.5	7.64	0.495	0.810	1170	146	127	7.50	60.3	24.7	15.8	1.70	3.49
W18X65	65.0	19.1	18.4	7.59	0.450	0.750	1070	133	117	7.49	54.8	22.5	14.4	1.69	2.73
W18X60	60.0	17.6	18.2	7.56	0.415	0.695	984	123	108	7.47	50.1	20.6	13.3	1.68	2.17
W18X55	55.0	16.2	18.1	7.53	0.390	0.630	890	112	98.3	7.41	44.9	18.5	11.9	1.67	1.66
W18X50	50.0	14.7	18.0	7.50	0.355	0.570	800	101	88.9	7.38	40.1	16.6	10.7	1.65	1.24
W18X46	46.0	13.5	18.1	6.06	0.360	0.605	712	90.7	78.8	7.25	22.5	11.7	7.43	1.29	1.22
W18X40	40.0	11.8	17.9	6.02	0.315	0.525	612	78.4	68.4	7.21	19.1	10.0	6.35	1.27	0.810
W18X35	35.0	10.3	17.7	6.00	0.300	0.425	510	66.5	57.6	7.04	15.3	8.06	5.12	1.22	0.506
W16X100	100	29.4	17.0	10.4	0.585	0.985	1490	198	175	7.10	186	54.9	35.7	2.51	7.73
W16X89	89.0	26.2	16.8	10.4	0.525	0.875	1300	175	155	7.05	163	48.1	31.4	2.49	5.45
W16X77	77.0	22.6	16.5	10.3	0.455	0.760	1110	150	134	7.00	138	41.1	26.9	2.47	3.57
W16X67	67.0	19.6	16.3	10.2	0.395	0.665	954	130	117	6.96	119	35.5	23.2	2.46	2.39
W16X57	57.0	16.8	16.4	7.12	0.430	0.715	758	105	92.2	6.72	43.1	18.9	12.1	1.60	2.22
W16X50	50.0	14.7	16.3	7.07	0.380	0.630	659	92.0	81.0	6.68	37.2	16.3	10.5	1.59	1.52
W16X45	45.0	13.3	16.1	7.04	0.345	0.565	586	82.3	72.7	6.65	32.8	14.5	9.34	1.57	1.11
W16X40	40.0	11.8	16.0	7.00	0.305	0.505	518	73.0	64.7	6.63	28.9	12.7	8.25	1.57	0.794
W16X36	36.0	10.6	15.9	6.99	0.295	0.430	448	64.0	56.5	6.51	24.5	10.8	7.00	1.52	0.545
W16X31	31.0	9.13	15.9	5.53	0.275	0.440	375	54.0	47.2	6.41	12.4	7.03	4.49	1.17	0.461
W16X26	26.0	7.68	15.7	5.50	0.250	0.345	301	44.2	38.4	6.26	9.59	5.48	3.49	1.12	0.262
W14X132	132	38.8	14.7	14.7	0.645	1.03	1530	234	209	6.28	548	113	74.5	3.76	12.3
W14X120	120	35.3	14.5	14.7	0.590	0.940	1380	212	190	6.24	495	102	67.5	3.74	9.37
W14X109	109	32.0	14.3	14.6	0.525	0.860	1240	192	173	6.22	447	92.7	61.2	3.73	7.12
W14X99	99.0	29.1	14.2	14.6	0.485	0.780	1110	173	157	6.17	402	83.6	55.2	3.71	5.37
W14X90	90.0	26.5	14.0	14.5	0.440	0.710	999	157	143	6.14	362	75.6	49.9	3.70	4.06

CE 120 – Spring 2020
Final Exam

W Shapes – Properties for designing



W = weight in plf
A = area, in.^{2}
I in moment of inertia, in.^{4}
Z = plastic modulus, in.^{3}
S = section modulus, in.^{3}
r = radius of gyration, in.
J = torsional constant, in.^{3}
All other dimensions in inches.

AISC_Manual_Label	W	A	d	b_f	t_w	t_f	I_x	Z_x	S_x	r_x	I_y	Z_y	S_y	r_y	J
W14X82	82.0	24.0	14.3	10.1	0.510	0.855	881	139	123	6.05	148	44.8	29.3	2.48	5.07
W14X74	74.0	21.8	14.2	10.1	0.450	0.785	795	126	112	6.04	134	40.5	26.6	2.48	3.87
W14X68	68.0	20.0	14.0	10.0	0.415	0.720	722	115	103	6.01	121	36.9	24.2	2.46	3.01
W14X61	61.0	17.9	13.9	10.0	0.375	0.645	640	102	92.1	5.98	107	32.8	21.5	2.45	2.19
W14X53	53.0	15.6	13.9	8.06	0.370	0.660	541	87.1	77.8	5.89	57.7	22.0	14.3	1.92	1.94
W14X48	48.0	14.1	13.8	8.03	0.340	0.595	484	78.4	70.2	5.85	51.4	19.6	12.8	1.91	1.45
W14X43	43.0	12.6	13.7	8.00	0.305	0.530	428	69.6	62.6	5.82	45.2	17.3	11.3	1.89	1.05
W14X38	38.0	11.2	14.1	6.77	0.310	0.515	385	61.5	54.6	5.87	26.7	12.1	7.88	1.55	0.798
W14X34	34.0	10.0	14.0	6.75	0.285	0.455	340	54.6	48.6	5.83	23.3	10.6	6.91	1.53	0.569
W14X30	30.0	8.85	13.8	6.73	0.270	0.385	291	47.3	42.0	5.73	19.6	8.99	5.82	1.49	0.380
W14X26	26.0	7.69	13.9	5.03	0.255	0.420	245	40.2	35.3	5.65	8.91	5.54	3.55	1.08	0.358
W14X22	22.0	6.49	13.7	5.00	0.230	0.335	199	33.2	29.0	5.54	7.00	4.39	2.80	1.04	0.208
W12X336	336	98.9	16.8	13.4	1.78	2.96	4060	603	483	6.41	1190	274	177	3.47	243
W12X305	305	89.5	16.3	13.2	1.63	2.71	3550	537	435	6.29	1050	244	159	3.42	185
W12X279	279	81.9	15.9	13.1	1.53	2.47	3110	481	393	6.16	937	220	143	3.38	143
W12X252	252	74.1	15.4	13.0	1.40	2.25	2720	428	353	6.06	828	196	127	3.34	108
W12X230	230	67.7	15.1	12.9	1.29	2.07	2420	386	321	5.97	742	177	115	3.31	83.8
W12X210	210	61.8	14.7	12.8	1.18	1.90	2140	348	292	5.89	664	159	104	3.28	64.7
W12X190	190	56.0	14.4	12.7	1.06	1.74	1890	311	263	5.82	589	143	93.0	3.25	48.8
W12X170	170	50.0	14.0	12.6	0.960	1.56	1650	275	235	5.74	517	126	82.3	3.22	35.6
W12X152	152	44.7	13.7	12.5	0.870	1.40	1430	243	209	5.66	454	111	72.8	3.19	25.8
W12X136	136	39.9	13.4	12.4	0.790	1.25	1240	214	186	5.58	398	98.0	64.2	3.16	18.5
W12X120	120	35.2	13.1	12.3	0.710	1.11	1070	186	163	5.51	345	85.4	56.0	3.13	12.9
W12X106	106	31.2	12.9	12.2	0.610	0.990	933	164	145	5.47	301	75.1	49.3	3.11	9.13
W12X96	96.0	28.2	12.7	12.2	0.550	0.900	833	147	131	5.44	270	67.5	44.4	3.09	6.85
W12X87	87.0	25.6	12.5	12.1	0.515	0.810	740	132	118	5.38	241	60.4	39.7	3.07	5.10
W12X79	79.0	23.2	12.4	12.1	0.470	0.735	662	119	107	5.34	216	54.3	35.8	3.05	3.84
W12X72	72.0	21.1	12.3	12.0	0.430	0.670	597	108	97.4	5.31	195	49.2	32.4	3.04	2.93
W12X65	65.0	19.1	12.1	12.0	0.390	0.605	533	96.8	87.9	5.28	174	44.1	29.1	3.02	2.18
W12X58	58.0	17.0	12.2	10.0	0.360	0.640	475	86.4	78.0	5.28	107	32.5	21.4	2.51	2.10
W12X53	53.0	15.6	12.1	10.0	0.345	0.575	425	77.9	70.6	5.23	95.8	29.1	19.2	2.48	1.58
W12X50	50.0	14.6	12.2	8.08	0.370	0.640	391	71.9	64.2	5.18	56.3	21.3	13.9	1.96	1.71
W12X45	45.0	13.1	12.1	8.05	0.335	0.575	348	64.2	57.7	5.15	50.0	19.0	12.4	1.95	1.26
W12X40	40.0	11.7	11.9	8.01	0.295	0.515	307	57.0	51.5	5.13	44.1	16.8	11.0	1.94	0.906
W12X35	35.0	10.3	12.5	6.56	0.300	0.520	285	51.2	45.6	5.25	24.5	11.5	7.47	1.54	0.741
W12X30	30.0	8.79	12.3	6.52	0.260	0.440	238	43.1	38.6	5.21	20.3	9.56	6.24	1.52	0.457
W12X26	26.0	7.65	12.2	6.49	0.230	0.380	204	37.2	33.4	5.17	17.3	8.17	5.34	1.51	0.300
W12X22	22.0	6.48	12.3	4.03	0.260	0.425	156	29.3	25.4	4.91	4.66	3.66	2.31	0.848	0.293
W12X19	19.0	5.57	12.2	4.01	0.235	0.350	130	24.7	21.3	4.82	3.76	2.98	1.88	0.822	0.180
W12X16	16.0	4.71	12.0	3.99	0.220	0.265	103	20.1	17.1	4.67	2.82	2.26	1.41	0.773	0.103

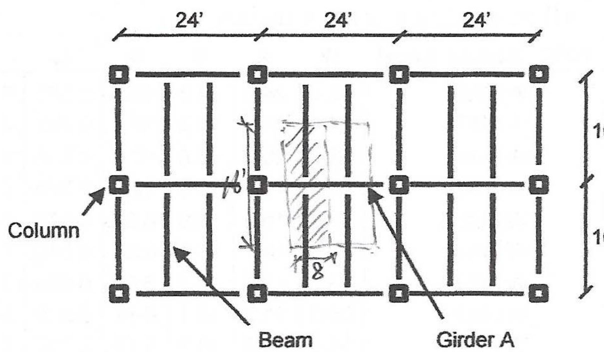
CE 120 – Spring 2020
Final Exam

Problem 1 (30 points) – The figure below shows the roof framing plan of a one-story wood building. The roof has a dead load of 24 psf, which can be assumed to include all dead load (including the beams and girders). The ceiling below is not plaster. The roof live load is 20 psf.

The wood is Douglas Fir – Larch (North), Dense Select Structural. The wood is seasoned.

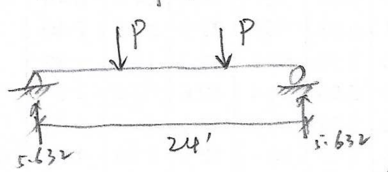
Design "Girder A" considering bending, shear and deflection.

Hint:
The mid-span deflection of a simply-supported beam with a point load P at the third-span is: $\delta = 0.018\frac{Pl^3}{EI}$



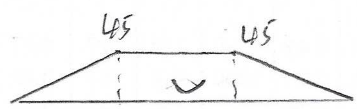
Roof plan view

$W_D = 24\text{ psf}$ $\quad W_L = 20\text{ psf}$

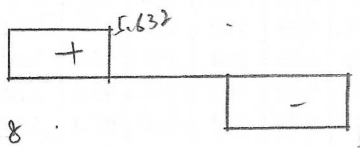


$P = (W_D + W_L) \times 16' \times 8'$
$= (24+20) \times 16 \times 8 = 5.632k$

M[k.ft]



V[k]



Assume 4x8

1). Bending stress.

$M_{max} = 45\text{ k.ft}$

$f_b = \frac{M_{max}}{S} \leq F_b \times C_F \times C_f \times LDF = 2400 \times 1.0 \times 1.0 \times 1.25 = 3000\text{psi}$

$S \geq \frac{45\text{k.ft} \times 10^3 \times 12}{3000\text{psi}} = 180\text{ in}^3$ Try $\boxed{10 \times 12}$ w/ $S = 209.40\text{ in}^3$

2). Shear stress.

$V_{max} = 5.632k$

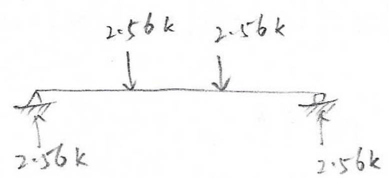
$f_v = \frac{3}{2}\frac{V}{A} \leq F_v \times LDF = 95 \times 1.25 = 118.75\text{ psi}$

$A \geq 71.14\text{ in}^2$ ok. since 10x12 has $A = 109.25\text{ in}^2$.

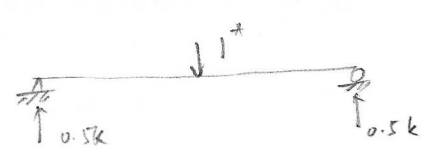
3). Deflections. seasoned wood. $k = 0.5$. $\delta_L \leq \frac{l}{240}$ $\quad \delta_{kD+L} \leq \frac{l}{180}$

$P_L = W_L \cdot 16 \times 8' = 2.56k$ $\quad P_{kD+L} = (0.5 \times 24 + 20) \times 16 \times 8 = 4.1k$

Real



virtual.



CE 120 – Spring 2020
Final Exam

Problem 1 (continued)

$$\delta_L = 0.018 \frac{P_L L^3}{EI} = 0.018 \times \frac{2.56\times10^3 \times (24\times12)^3}{1.9\times10^6 \times I} \leq \frac{l}{240}$$

$$I \geq 482.8 \text{ in}^4$$

$$\delta_{KD+L} = 0.018 \frac{P_{KD+L} \cdot L^3}{EI} = 0.018 \times \frac{4.1\times10^3 \times (24\times12)^3}{1.9\times10^6 \cdot I} \leq \frac{l}{180}$$

$I \geq 579.9$ in^4 → governs.

ok. since 10x12 has $I = 1204.03$ in^4.

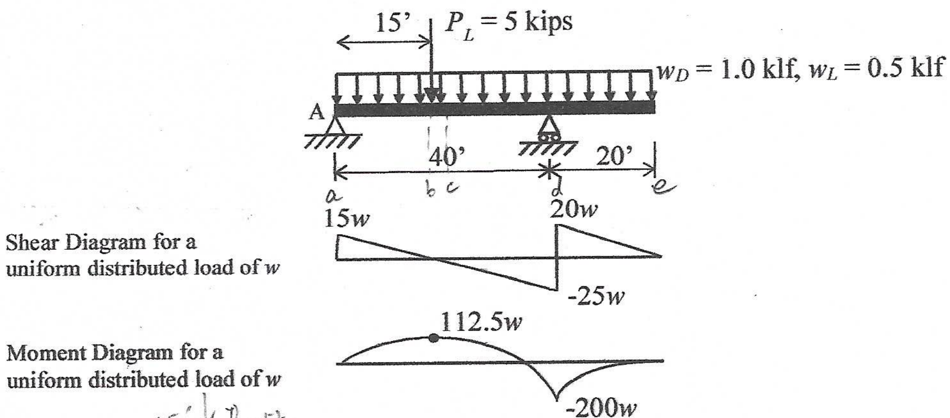
→ use **10x12** girder.

CE 120 – Spring 2020
Final Exam

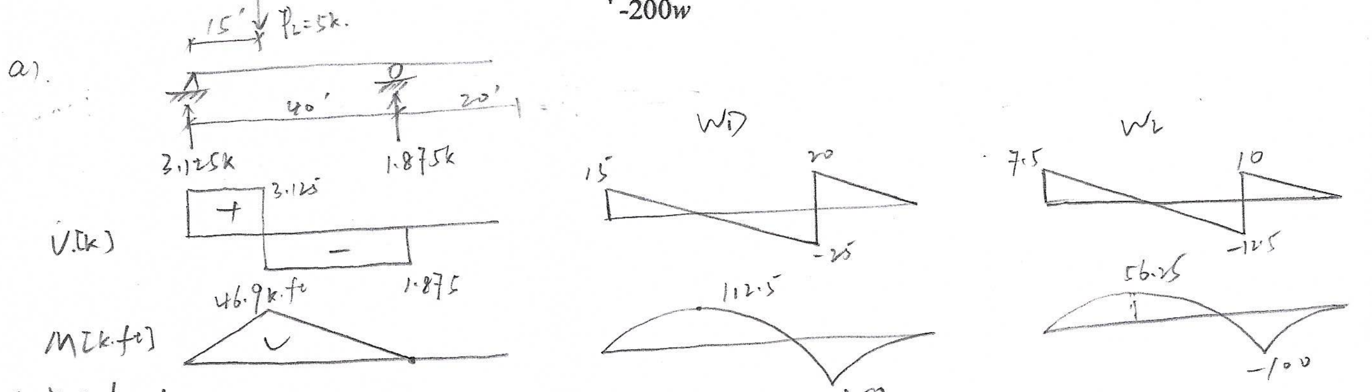
Problem 2 (30 points) – The figure below shows a steel beam with distributed dead load of $w_D = 1.0$ klf, a distributed live load of $w_L = 0.5$ klf, and a point live load of $P_L = 5$ kips at the location shown below. The beam is a W-shape and the steel is Grade A36.

(a) Design the beam considering only bending and shear. Do not consider deflections.

(b) Now assume that the point live load and the distributed live load are the same magnitude, but they are movable and can be applied anywhere on the beam. Re-design the beam considering only bending and shear. Do not consider deflections.



a).



① Find M_u.

@ point c. $M_u = 1.4 M_D = 157.5$ k.ft

$M_u = 1.2 M_D + 1.6 M_L = 1.2 \times 112.5 + 1.6(56.25 + 46.9 \times \frac{20}{25}) = 285$ k.ft

@ point d. $M_u = 1.4 M_D = -280$ k.ft

$M_u = 1.2 M_D + 1.6 M_L = -400$ k.ft → governs.

②. Find V_u.

@ d.left. $V_u = 1.4 V_D = -35$ k

$V_u = 1.2 V_D + 1.6 V_L = -53$ k → governs.

@ d.right. $V_u = 1.4 V_D = 28$ k

$V_u = 1.2 V_D + 1.6 V_L = 40$ k

1). Bending $\phi M_n \geq M_u$

$\phi(Z f_y) \geq +400 \times 12$

$Z \geq \frac{+4800 \text{ k·in}}{0.9 \times 36 \text{ ksi}} = 148 \text{ in}^3$ Try W16×77.

CE 120 – Spring 2020
Final Exam

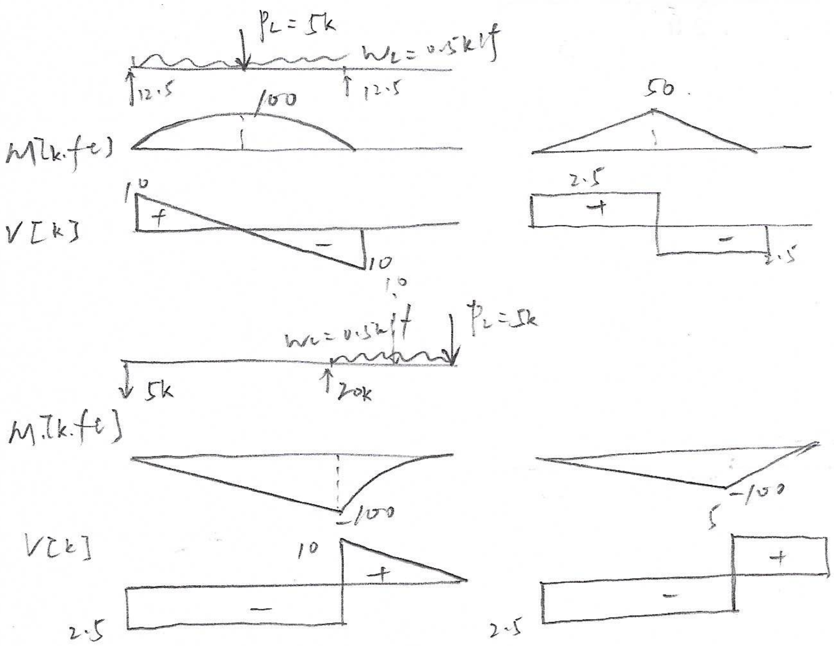
Problem 2 (continued)

2). shearing. $V_u \le \phi V_n = \phi (d t_w)(0.6 f_y)$.

$$d t_w \geq \frac{V_u}{0.6 f_y \cdot \phi} = \frac{53k}{0.6 \times 36 \times 0.9} = 2.73\ in^2 \quad ok.$$

→ use $\boxed{W\,16 \times 77}$

b). For Live Load.



@ b.

$M_u = 1.2 M_D + 1.6 M_L = 1.2 \times 112.5 + 1.6 (100 ft)$
$= 375\ k.ft$

@ c, left

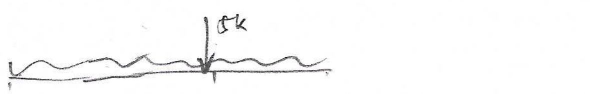
$V_u = 1.2 V_D + 1.6 V_L$
$= 1.2 \times (-25) + 1.6(-10 - 2.5)$
$= -50k$

@ c

$M_u = 1.2 M_D + 1.6 M_L$
$= 1.2 \times (-200) + 1.6 \times (-100 + (-100))$
$= \boxed{-560\ k.ft}$

@ c, right

$V_u = 1.2 V_D + 1.6 V_L$
$= 1.2 \times (20) + 1.6 (10 + 5)$
$= 48k$



@ c. left $V_u = 1.2 V_D + 1.6 V_L$
$= 1.2 \times (-25) + 1.6(-12.5 + (-5))$
$= \boxed{-58\ k}$

①. Bearing

$\phi M_n \geq M_u$
$\phi (Z f_y) \geq +560\ k.ft$
$Z \geq \frac{+560 \times 12\ k.in}{0.9 \times 36 ksi} = 207\ in^3$. Try $\boxed{W\,18 \times 97}$

②. Shearing

$V_u \le \phi V_n = \phi (d t_w)(0.6 f_y)$

$$d t_w \geq \frac{+58k}{0.6 \times 36 \times 0.9} = 2.98\ in^2 \quad ok$$

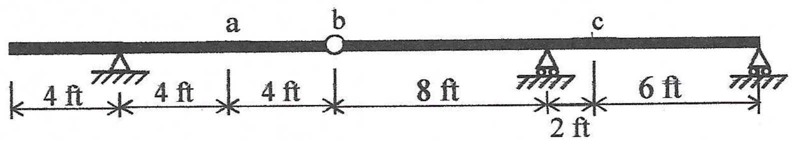
use $\boxed{W\,18 \times 97}$

CE 120 – Spring 2020
Final Exam

Problem 3 (15 points) – The beam shown below has a hinge at point b. Points a and c are defined by the dimensions. Assume all loads only act downwards.

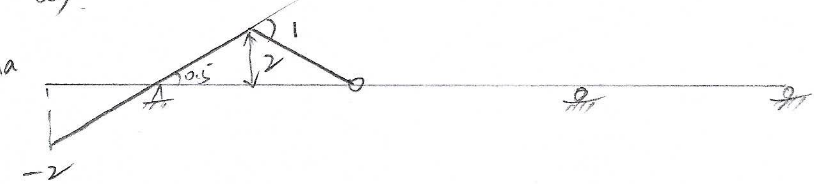
(a) Draw the influence line for the moment at point a.

(b) Draw the influence line for the shear at point c.

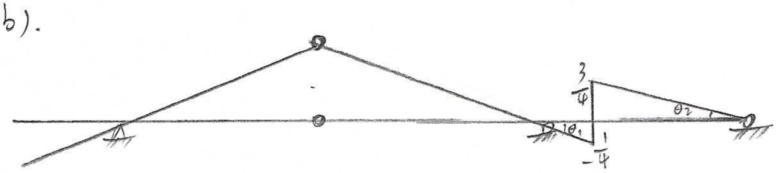


a).

IL for Ma



b).



$$\begin{cases} \theta_1 \cdot 2 + \theta_2 \cdot 6 = 1 \\ \theta_1 = \theta_2 \end{cases}$$

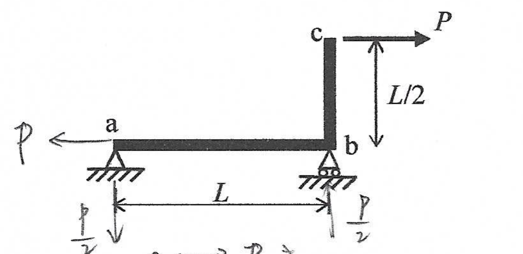
$$\theta_1 = \theta_2 = \frac{1}{8}$$

CE 120 – Spring 2020
Final Exam

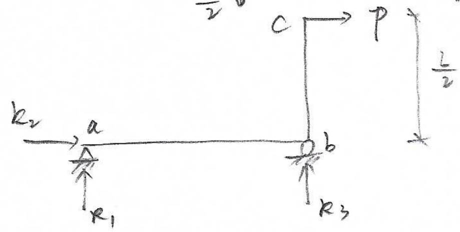
Problem 4 (25 points) –The beam shown below has a bending stiffness of EI and is subjected to a point load P.

(a) Draw the shear and moment diagrams.

(b) Determine the horizontal displacement of point c.



a).



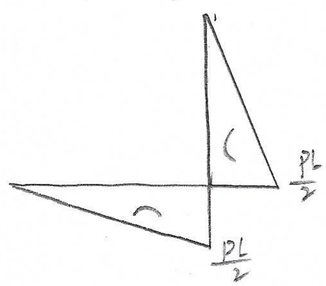
$\Sigma F_x = R_2 + P = 0 \rightarrow R_2 = -P$

$\Sigma F_y = R_1 + R_3 = 0$

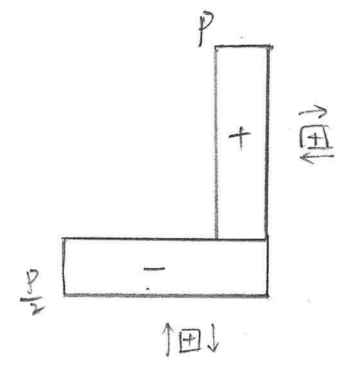
$\circlearrowleft + \Sigma M_a = P \cdot \frac{L}{2} - R_3 \cdot L = 0 \rightarrow R_3 = \frac{P}{2}$

$R_1 = -\frac{P}{2}$

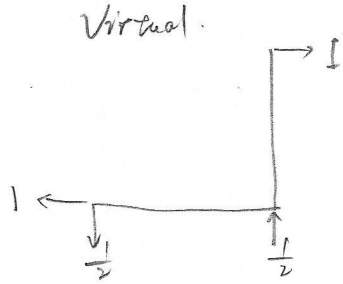
[M]



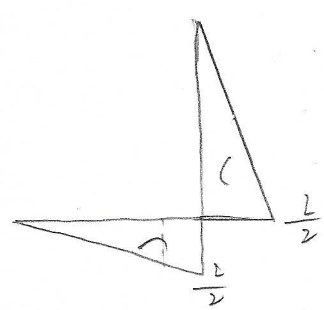
[V]



b) Virtual.



[M*]



$$\delta_c = \frac{A_m}{EI} \cdot M^*_{\bar{x}m}$$

$$= \frac{1}{EI}\left[\frac{PL}{2} \times L \times \frac{1}{2} \times \left(\frac{2}{3} \cdot \frac{L}{2}\right) + \left(\frac{PL}{2} \times \frac{L}{2} \times \frac{1}{2}\right) \times \left(\frac{2}{3} \cdot \frac{L}{2}\right)\right]$$

$$= \frac{1}{EI}\left(\frac{PL^3}{12} + \frac{PL^3}{24}\right) = \boxed{\frac{PL^3}{8EI}}$$

Problem 4 (continued)