NOTE: Configurations, geometry, units, AND questions can and will be changed on the final exam.

ARCH 331. Practice Final Examination

*Note: No aids are allowed for part 1. For part 2, a reference document and any necessary charts will be provided (also posted), and two single sides of letter sized paper with notes are allowed along with a silent, **non-programmable** calculator.*

Part 1)   *Worth 10%   (conceptual questions)*

Part 2)   Clearly show all your work and record your **final answers in the boxes**.

Question 1)   Worth 45%

- Solid slabs 5 in.-thick are integrally supported on three beams in a two-story frame. The center to center beam spacing is 25 ft.
- The floor slab has a dead load of 30 lb/ft^2 (not including self weight), and a live load of 50 lb/ft^2.
- The roof slab has a dead load of 25 lb/ft^2 (not including self weight) and live load of 20 lb/ft^2.
- The cross section geometry of the beams supporting the slab is shown in Figure 1a. The 12 in. by 20 in. beam has 6 #-8 bars (two layers), #3 stirrups, and I = 5200 in^4. The self weight is 233 lb/ft.
- The material is light-weight concrete (140 lb/ft^3) with E = 3,460 ksi and f'_c = 4,000 psi with grade 60 reinforcement.
- The beams are supported on girders. Figure 1b shows the *factored* total loading on a girder section in the frame from live, dead, and wind loading.
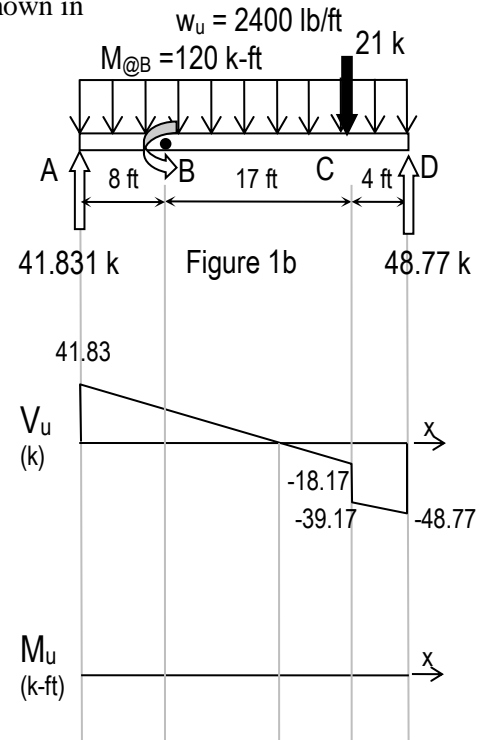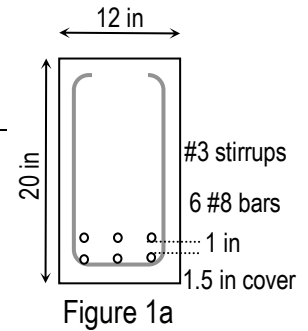
FIND:

a) If the *first* floor slab is adequate for shear assuming *d*=4 in. and the clear span, l_n = 24 ft.
b) The completed bending moment diagram and maximum factored moment for the girder (Figure 1b & c).
c) If the beam is adequate for bending and reinforcing when M_u = 275 k-ft, knowing d = 16.625 in..
d) The recommended reinforcement ratio, ρ, for the beam when the design moment, M_u = 180 k-ft.
e) The most economical W section of A992 (F_y = 50 ksi) steel that could be used for a 29 ft simply supported beam using the provided Beam Design Moment diagrams if the unbraced length is 12.5 ft and M_u = 150 k-ft *at midspan* when no self weight has been included (yet).
f) The maximum deflection of the beam shown in Figure 1b for a W 12 x 53 when end A is considered pinned and end D is considered fixed when there is an unfactored distributed load of 1600 lb/ft over the entire length. E = 30 x 10^3 ksi, I_x = 425 in^4, and I_y = 95.8 in^4.
g) The minimum dimension required for a square footing 18 in. deep when the dead load is 105.7 kips and the live load is 36.5 kips for a soil with $q_{allowed}$ = 1800 lb/ft^2 and a density of 80 lb/ft^3. Assume normal weight concrete.
h) The maximum two-way design shear in a 10 ft. square footing having the loads in part g) when the column is 18 in. square and *d* = 13.5 in..

Figure 1a

Figure 1b

Figure 1c

Disclaimer: Answers have NOT been painstakingly researched.

a)	yes (2567 lb/unit < φVc)	b)			
c)	no (ρ > ρ.005, φMn = 280.3 k-ft)	d)	0.013	e)	
f)	0.83 in	g)	9.16 ft	h)	172.5 k

Question 2)   *Worth 45%*

- A parallel chord truss is shown in the Figure 2a supports dead load and 7 day roof live load. It also has a lateral live load at B of 3 kips. The reactions at the pin and roller supports have been determined to be:
  $A_x = -3$ k, $A_y = 7.33$ k and $E = 8.67$ k.
- The truss is constructed with 5 1/8 in. x 12 in. glu-lam lumber for the top and bottom chords having
  $E = 1.85 \times 10^6$ psi, $\alpha = 3.8 \times 10^{-6}$ /°F, $F_c = 1700$ psi (no adjustment factors); $F'_p = 750$ psi (with adjustment factors).
- The top chord is connected to a vertical web member as shown in Figure 2b with $2 - \frac{3}{4}$" A 325-SC bolts, standard bolt holes and 3 in. spacing.
- The truss is constructed with a L 4 x 3.5 x ½ in. steel angle welded flush to a 0.75 in. x 3 in. plate for the vertical web members as shown in Figures 2b and c.
- The truss is constructed with C 3 x 5 steel channel sections for the diagonal members as shown in Figures 2 b and c. There is a lap splice as shown.
- All steel is A36 ($F_y = 36$ ksi, $F_u = 58$ ksi). The weld material is EXX60.
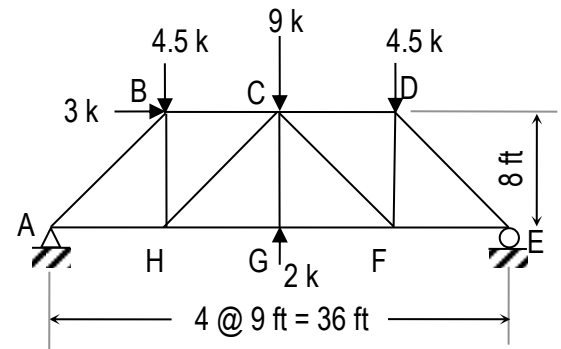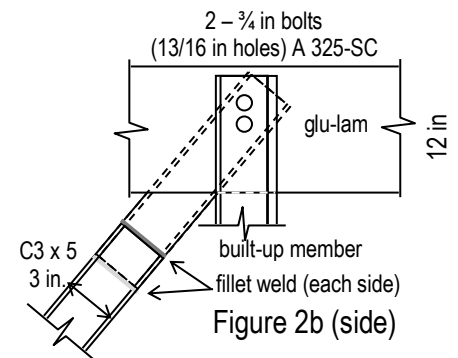

Figure 2a

Figure 2b (side)

FIND:

i) The member forces in BC and HC using the method of sections.
j) The moment of inertia about the *x* axis for the vertical steel web members by completing the chart of Table 2 when $\hat{y} = 1.196$" from the top of the section.
k) The maximum (factored) compressive load for the vertical steel web members when $r_x = 1.01$ in. and $r_y = 1.80$ in..
l) If the top glu-lam chord from C to D is adequate with a member force of 75 kips in compression and a maximum unbraced length of 9 ft. laterally. The ends are pinned in the plane of the truss.
m) The size of the weld required for the lap splice with a factored member force of 40.5 kips in tension.
n) The maximum (factored) shear in the bolts of the connection shown considering the vertical member only.
o) The *design capacity* of the bolted connection shown with respect to bearing in the diagonal member ($t_w = 0.258$ in.) **and** the top chord.
p) The *design capacity* of the bolted connection shown with respect to tension for the vertical steel member assuming a shear lag factor, $U = 0.80$.
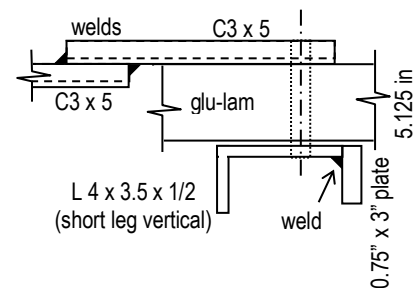
Figure 2c (top)

Table 2

	A (in²)	I_x (in⁴)	d_y (in)	Ad_y^2 (in³)
angle	3.5			
plate	2.25			

Disclaimer: Answers have NOT been painstakingly researched.

i)	BC = 11.25 k (C)			j)	5.82 in⁴
k)	115.6 k	l)		m)	3/8 in.
n)	19.0 k	o)	5.8 k (78.3 k)	p)	184.9 k (186.3 k)

Table 3-10 (continued)
W Shapes
Available Moment vs. Unbraced Length
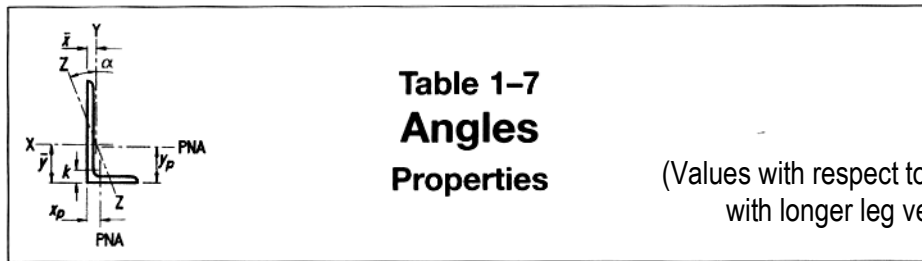
Table 1–7
Angles
Properties

(Values with respect to orientation with longer leg vertical)

Table 1–7 (continu
Angles
Properties

Shape	k	Wt.	Area, A	Axis X-X							Flexural-Torsional Properties			Axis Y-Y					
				I	S	r	$\bar{y}$	Z	y_p	J	C_w	$\bar{r}_o$	I	S	r	$\bar{x}$	Z	x_p
	in.	lb/ft	in.²	in.⁴	in.³	in.	in.	in.³	in.	in.⁴	in.⁶	in.	in.⁴	in.³	in.	in.	in.³	in.
L4×4×³/₄	1¹/₈	18.5	5.44	7.62	2.79	1.18	1.27	5.02	0.679	1.02	1.12	2.10	7.62	2.79	1.18	1.27	5.01	0.679
×⁵/₈	1	15.7	4.61	6.62	2.38	1.20	1.22	4.28	0.576	0.610	0.680	2.13	6.62	2.38	1.20	1.22	4.28	0.576
×¹/₂	⁷/₈	12.8	3.75	5.52	1.96	1.21	1.18	3.50	0.468	0.322	0.366	2.16	5.52	1.96	1.21	1.18	3.50	0.468
×⁷/₁₆	¹³/₁₆	11.3	3.31	4.93	1.73	1.22	1.15	3.10	0.413	0.220	0.252	2.18	4.93	1.73	1.22	1.15	3.10	0.413
×³/₈	³/₄	9.80	2.86	4.32	1.50	1.23	1.13	2.69	0.357	0.141	0.162	2.19	4.32	1.50	1.23	1.13	2.68	0.357
×⁵/₁₆	¹¹/₁₆	8.20	2.40	3.67	1.27	1.24	1.11	2.26	0.300	0.0832	0.0963	2.21	3.67	1.27	1.24	1.11	2.26	0.300
×¹/₄	⁵/₈	6.60	1.94	3.00	1.03	1.25	1.08	1.82	0.242	0.0438	0.0505	2.22	3.00	1.03	1.25	1.08	1.82	0.242
L4×3¹/₂×¹/₂	⁷/₈	11.9	3.50	5.30	1.92	1.23	1.24	3.46	0.497	0.301	0.302	2.03	3.76	1.50	1.04	0.994	2.69	0.438
×³/₈	³/₄	9.10	2.67	4.15	1.48	1.25	1.20	2.66	0.433	0.132	0.134	2.06	2.96	1.16	1.05	0.947	2.06	0.334
×⁵/₁₆	¹¹/₁₆	7.70	2.25	3.53	1.25	1.25	1.17	2.24	0.401	0.0782	0.0798	2.08	2.52	0.980	1.06	0.923	1.74	0.281
×¹/₄	⁵/₈	6.20	1.81	2.89	1.01	1.26	1.14	1.81	0.368	0.0412	0.0419	2.09	2.07	0.794	1.07	0.897	1.40	0.227
L4×3×⁵/₈	1	13.6	3.89	6.01	2.28	1.23	1.37	4.08	0.810	0.529	0.472	1.91	2.85	1.34	0.845	0.867	2.45	0.498
×¹/₂	⁷/₈	11.1	3.25	5.02	1.87	1.24	1.32	3.36	0.747	0.281	0.255	1.94	2.40	1.10	0.858	0.822	1.99	0.407
×³/₈	³/₄	8.50	2.48	3.94	1.44	1.26	1.27	2.60	0.683	0.123	0.114	1.97	1.89	0.851	0.873	0.775	1.52	0.311

Available Critical Stress, $\phi_c F_{cr}$, for Compression Members, ksi ($F_y = 36$ ksi and $\phi_c = 0.90$)

KL/r	$\phi_c F_{cr}$	KL/r	$\phi_c F_{cr}$	KL/r	$\phi_c F_{cr}$	KL/r	$\phi_c F_{cr}$	KL/r	$\phi_c F_{cr}$	KL/r	$\phi_c F_{cr}$
1	32.4	41	29.7	81	22.9	121	15.0	161	8.72		
2	32.4	42	29.5	82	22.7	122	14.8	162	8.61		
3	32.4	43	29.4	83	22.5	123	14.6	163	8.50		
4	32.4	44	29.3	84	22.3	124	14.4	164	8.40		
5	32.4	45	29.1	85	22.1	125	14.2	165	8.30		
6	32.3	46	29.0	86	22.0	126	14.0	166	8.20		
7	32.3	47	28.8	87	21.8	127	13.9	167	8.10		
8	32.3	48	28.7	88	21.6	128	13.7	168	8.00		
9	32.3	49	28.6	89	21.4	129	13.5	169	7.91		
10	32.2	50	28.4	90	21.2	130	13.3	170	7.82		
11	32.2	51	28.3	91	21.0	131	13.1	171	7.73		
12	32.2	52	28.1	92	20.8	132	12.9	172	7.64		
13	32.1	53	27.9	93	20.5	133	12.8	173	7.55		
14	32.1	54	27.8	94	20.3	134	12.6	174	7.46		
15	32.0	55	27.6	95	20.1	135	12.4	175	7.38		
16	32.0	56	27.5	96	19.9	136	12.2	176	7.29		
17	31.9	57	27.3	97	19.7	137	12.0	177	7.21		
18	31.9	58	27.1	98	19.5	138	11.9	178	7.13		
19	31.8	59	27.0	99	19.3	139	11.7	179	7.05		
20	31.7	60	26.8	100	19.1	140	11.5	180	6.97		
21	31.7	61	26.6	101	18.9	141	11.4	181	6.90		
22	31.6	62	26.5	102	18.7	142	11.2	182	6.82		
23	31.5	63	26.3	103	18.5	143	11.0	183	6.75		
24	31.4	64	26.1	104	18.3	144	10.9	184	6.67		
25	31.4	65	25.9	105	18.1	145	10.7	185	6.60		
26	31.3	66	25.8	106	17.9	146	10.6	186	6.53		
27	31.2	67	25.6	107	17.7	147	10.5	187	6.46		
28	31.1	68	25.4	108	17.5	148	10.3	188	6.39		
29	31.0	69	25.2	109	17.3	149	10.2	189	6.32		
30	30.9	70	25.0	110	17.1	150	10.0	190	6.26		
31	30.8	71	24.8	111	16.9	151	9.91	191	6.19		
32	30.7	72	24.7	112	16.7	152	9.78	192	6.13		
33	30.6	73	24.5	113	16.5	153	9.65	193	6.06		
34	30.5	74	24.3	114	16.3	154	9.53	194	6.00		
35	30.4	75	24.1	115	16.2	155	9.40	195	5.94		
36	30.3	76	23.9	116	16.0	156	9.28	196	5.88		
37	30.1	77	23.7	117	15.8	157	9.17	197	5.82		
38	30.0	78	23.5	118	15.6	158	9.05	198	5.76		
39	29.9	79	23.3	119	15.4	159	8.94	199	5.70		
40	29.8	80	23.1	120	15.2	160	8.82	200	5.65		