

Arch324

STRUCTURES II

Winter 2026
Recitation

FACULTY: Prof. Peter von Bülow
GSI: Hui Zhu huizz@umich.edu

Recitation Guidelines

Homework Problem

No Lab today

- If you received an **email** last week about **recalculating**, or didn't get a chance to complete it in class, you're welcome to continue working on it today
- Try to attend all sessions. Unexcused absences will **affect your grade** starting from the second missed class.

Analysis Example - HW2

2. Wood Beam Design

Design a **2x dimensioned lumber** floor joist to carry the given dead + live floor load (**neglect joist selfweight**). Assume the floor meets conditions of 4.4.1 so **CL=1.0**. Also **Ct", Cfu," and Ci = 1.0**. Find the short term deflection of your chosen beam under live load only (100% LL is short term). Compare your LL deflection with the code limit of $L/360$.

DATASET: 1

-2-

-3-

Wood Species

SPRUCE-
PINE-FIR

Wood Grade

No.1/No.2

Span

15 FT

Joist Spacing, o.c.

12 IN

Moisture Content, m.c.

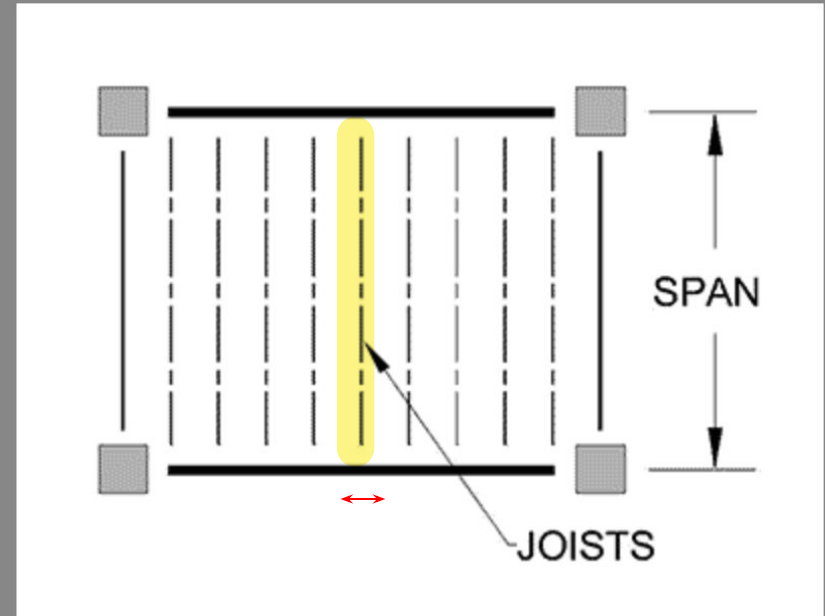
15 %

Floor DL

7 PSF

Floor LL

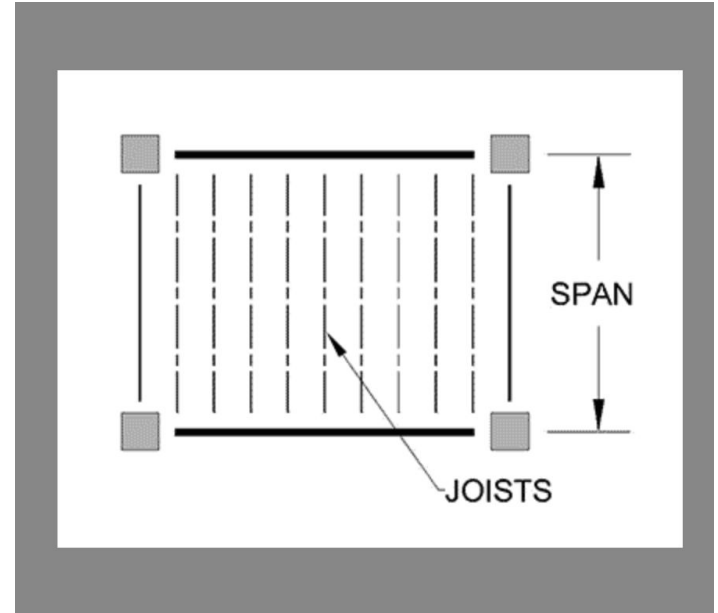
35 PSF



Analysis Example - HW2

20 Questions

#	Question	Your Response
1	Tabulated Allow. Bending Stress, F_b	<input type="text"/> PSI
2	Tabulated Allow. Shear Stress, F_v	<input type="text"/> PSI
3	Tabulated Modulus of Elasticity, E	<input type="text"/> PSI
4	Total Applied Floor Load, (DL+LL)	<input type="text"/> PSF
5	Load on Joist, w	<input type="text"/> PLF
6	Actual Beam Bending Moment, M	<input type="text"/> FT-LB
7	Actual Maximum Shear Force (at reaction) , V	<input type="text"/> LBS
8	Nominal Depth of the Final Joist Used	<input type="text"/> IN
9	Size Factor, CF	<input type="text"/>
10	Repetitive Member Factor, C_r	<input type="text"/>
11	Wet Service Factor for F_b , CM_b	<input type="text"/>
12	Wet Service Factor for F_v , CM_v	<input type="text"/>
13	Factored Allow. Bending Stress, F'_b	<input type="text"/> PSI
14	Factored Allow. Shear Stress, F'_v	<input type="text"/> PSI
15	Actual Bending Stress, f_b_{actual}	<input type="text"/> PSI
16	Actual Shear Stress, f_v_{actual}	<input type="text"/> PSI
17	Factored Allow. Modulus of Elasticity, E'	<input type="text"/> PSI
18	Short Term Deflection for 100% LL	<input type="text"/> IN
19	Short Term Deflection Limit for $L/360$	<input type="text"/> IN
20	Deflection Passing: enter "1" for pass or "0" for fail	<input type="text"/> (1 or 0)



Answer HW2

20 Questions

#	<u>Question</u>	<u>Correct Answer</u>
1	Tabulated Allow. Bending Stress, F _b	875 PSI
2	Tabulated Allow. Shear Stress, F _v	135 PSI
3	Tabulated Modulus of Elasticity, E	1400000 PSI
4	Total Applied Floor Load, (DL+LL)	42 PSF
5	Load on Joist, w	42 PLF
6	Actual Beam Bending Moment, M	1181.25 FT-LB
7	Actual Maximum Shear Force (at reaction) , V	315 LBS
8	Nominal Depth of the Final Joist Used	8 IN
9	Size Factor, C _F	1.2
10	Repetitive Member Factor, C _r	1.15
11	Wet Service Factor for F _b , C _{M_b}	1
12	Wet Service Factor for F _v , C _{M_v}	1
13	Factored Allow. Bending Stress, F' _b	1207.5 PSI
14	Factored Allow. Shear Stress, F' _v	135 PSI
15	Actual Bending Stress, f _{b_} actual	1078.715815 PSI
16	Actual Shear Stress, f _{v_} actual	43.44827586 PSI
17	Factored Allow. Modulus of Elasticity, E'	1400000 PSI
18	Short Term Deflection for 100% LL	0.597810488 IN
19	Short Term Deflection Limit for L/360	0.5 IN
20	Deflection Passing: enter "1" for pass or "0" for fail	0 (1 or 0)

Analysis Example - HW2

Q1-Q3

Wood Species	SPRUCE-PINE-FIR
Wood Grade	No.1/No.2

- 1 Tabulated Allow. Bending Stress, F_b
- 2 Tabulated Allow. Shear Stress, F_v
- 3 Tabulated Modulus of Elasticity, E

Q1 $F_b=875$ PSI

Q2 $F_v=135$ PSI

Q3 $E=1400000$

Table 4A Reference Design Values for Visually Graded Dimension Lumber (2" - 4" thick)^{1,2,3}

(All species except Southern Pine— see Table 4B) (Tabulated design values are for normal load duration and dry service conditions. See NDS 4.3 for a comprehensive description of design value adjustment factors.)

USE WITH TABLE 4A ADJUSTMENT FACTORS

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)							Specific Gravity ^A G	Grading Rules Agency
		Bending	Tension parallel to grain	Shear parallel to grain	Compression perpendicular to grain	Compression parallel to grain	Modulus of Elasticity			
		F_b	F_t	F_v	$F_{c\perp}$	F_c	E	E_{min}		
RED OAK										
Select Structural	2" & wider	1,150	675	170	820	1,000	1,400,000	510,000	0.67	NELMA
No. 1		825	500	170	820	825	1,300,000	470,000		
No. 2		800	475	170	820	625	1,200,000	440,000		
No. 3	475	275	170	820	375	1,100,000	400,000			
Stud	2" & wider	625	375	170	820	400	1,100,000	400,000		
Construction	2" - 4" wide	925	550	170	820	850	1,200,000	440,000		
Standard		525	300	170	820	650	1,100,000	400,000		
Utility		250	150	170	820	425	1,000,000	370,000		
REDWOOD										
Select Structural	2" & wider	1,100	625	160	425	1,100	1,100,000	400,000	0.37	RIS
No. 1		775	450	160	425	900	1,100,000	400,000		
No. 2		725	425	160	425	700	1,000,000	370,000		
No. 3	425	250	160	425	400	900,000	330,000			
Stud	2" & wider	575	325	160	425	450	900,000	330,000		
Construction	2" - 4" wide	825	475	160	425	925	900,000	330,000		
Standard		450	275	160	425	725	900,000	330,000		
Utility		225	125	160	425	475	800,000	290,000		
SPRUCE-PINE-FIR										
Select Structural	2" & wider	1,250	700	135	425	1,400	1,500,000	550,000	0.42	NLGA
No. 1/ No. 2		875	450	135	425	1,150	1,400,000	510,000		
No. 3		500	250	135	425	650	1,200,000	440,000		
Stud	2" & wider	675	350	135	425	725	1,200,000	440,000		
Construction	2" - 4" wide	1,000	500	135	425	1,400	1,300,000	470,000		
Standard		550	275	135	425	1,150	1,200,000	440,000		
Utility		275	125	135	425	750	1,100,000	400,000		

Analysis Example - HW2

Other wood species (Table 4A)

Table 4A Reference Design Values for Visually Graded Dimension Lumber (2" - 4" thick)^{1,2,3}

(All species except Southern Pine— see Table 4B) (Tabulated design values are for normal load duration and dry service conditions. See NDS 4.3 for a comprehensive description of design value adjustment factors.)

USE WITH TABLE 4A ADJUSTMENT FACTORS

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)						Modulus of Elasticity	Specific Gravity ⁴	Grading Rules Agency
		Bending	Tension parallel to grain	Shear parallel to grain	Compression perpendicular to grain	Compression parallel to grain				
		F _b	F _t	F _v	F _{c⊥}	F _c	E	E _{min}	G	

Winter 2026

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Discussions

Grades

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Canvas - Files - NDS 2018 - AWC NDS2018 Supplement - Page 33 to 38

Analysis Example - HW2

Q4-Q7

Given:

DL=7 PSF

LL=35 PSF

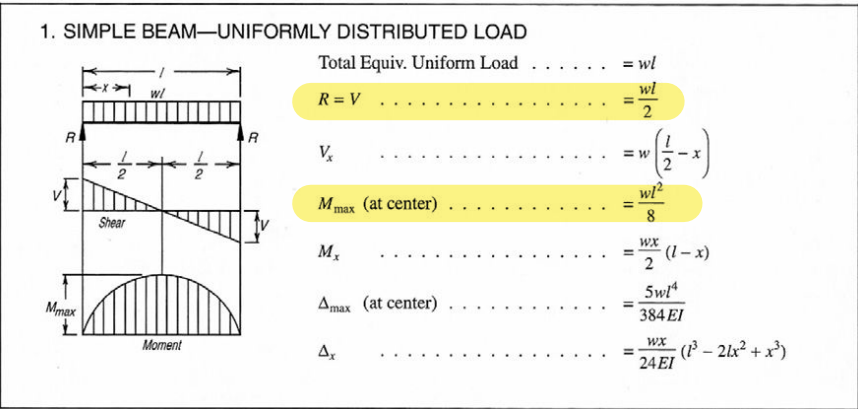
Joist spacing, o.c.=12 IN

Span=15 IN

Determine Beam Forces

by superposition equations

4	Total Applied Floor Load, (DL+LL)	<input type="text"/>	PSF
5	Load on Joist, w	<input type="text"/>	PLF
6	Actual Beam Bending Moment, M	<input type="text"/>	FT-LB
7	Actual Maximum Shear Force (at reaction) , V	<input type="text"/>	LBS



Q4 DL+LL=7+35=42 PSF

neglect joist selfweight

$w=(DL+LL)(o.c.)/12=PLF$

Q5 $w=(7+35)12/12=42$ PLF

$l=Span=15$

Q6 $M=wl^2/8=42 \times 15^2/8=1181.25$ FT-LB

Q7 $V=wl/2=42 \times 15/2=315$ LBS

Analysis Example - HW2

Q8-Q16

Adjustment Factors

Table 4.3.1 – Applicability of Adjustment Factors for Sawn Lumber

	ASD only	ASD and LRFD											LRFD only		
		Load Duration Factor	Wet Service Factor	Temperature Factor	Beam Stability Factor	Size Factor	Flat Use Factor	Incising Factor	Repetitive Member Factor	Column Stability Factor	Buckling Stiffness Factor	Bearing Area Factor	Format Conversion Factor	Resistance Factor	Time Effect Factor
													K_F	ϕ	
$F_b' = F_b$	x	C_D	C_M	C_t	C_L	C_F	C_{fu}	C_i	C_r	-	-	-	2.54	0.85	λ
$F_t' = F_t$	x	C_D	C_M	C_t	-	C_F	-	C_i	-	-	-	-	2.70	0.80	λ
$F_v' = F_v$	x	C_D	C_M	C_t	-	-	-	C_i	-	-	-	-	2.88	0.75	λ
$F_c' = F_c$	x	C_D	C_M	C_t	-	C_F	-	C_i	-	C_p	-	-	2.40	0.90	λ
$F_{c\perp}' = F_{c\perp}$	x	-	C_M	C_t	-	-	-	C_i	-	-	-	C_b	1.67	0.90	-
$E' = E$	x	-	C_M	C_t	-	-	C_{fu}^1	C_i	-	-	-	-	-	-	-
$E_{min}' = E_{min}$	x	-	C_M	C_t	-	-	C_{fu}^1	C_i	-	-	C_T	-	1.76	0.85	-

- 8 Nominal Depth of the Final Joist Used
- 9 Size Factor, CF
- 10 Repetitive Member Factor, Cr
- 11 Wet Service Factor for Fb, CM_b
- 12 Wet Service Factor for Fv, CM_v
- 13 Factored Allow. Bending Stress, F'b
- 14 Factored Allow. Shear Stress, F'v
- 15 Actual Bending Stress, fb_actual
- 16 Actual Shear Stress, fv_actual

¹ Where sawn lumber of Beam and Stringer grades is subject to loads causing flatwise bending or buckling, reference modulus of elasticity (E or E_{min}) shall be multiplied by the flat use factor, C_{fu}, specified in Table 4D of the NDS Supplement; otherwise, C_{fu} = 1.0.

Analysis Example - HW2

Q10-Q12

Repetitive Member Factor, C_r

Bending design values, F_b , for dimension lumber 2" to 4" thick shall be multiplied by the repetitive member factor, $C_r = 1.15$, when such members are used as joists, truss chords, rafters, studs, planks, decking, or similar members which are in contact or spaced not more than 24" on center, are not less than 3 in number and are joined by floor, roof, or other load distributing elements adequate to support the design load.

Flat Use Factor, C_{fu}

Bending design values adjusted by size factors are based on edgewise use (load applied to narrow face). When dimension lumber is used flatwise (load applied to wide face), the bending design value, F_b , shall also be permitted to be multiplied by the following flat use factors:

Flat Use Factors, C_{fu}		
Width (depth)	Thickness (breadth)	
	2" & 3"	4"
2" & 3"	1.0	—
4"	1.1	1.0
5"	1.1	1.05
6"	1.15	1.05
8"	1.15	1.05
10" & wider	1.2	1.1

Wet Service Factor, C_M

When dimension lumber is used where moisture content will exceed 19% for an extended time period, design values shall be multiplied by the appropriate wet service factors from the following table:

Wet Service Factors, C_M					
F_b	F_t	F_v	$F_{c\perp}$	F_c	E and E_{min}
0.85*	1.0	0.97	0.67	0.8**	0.9

* when $(F_b)(C_r) \leq 1,150$ psi, $C_M = 1.0$

** when $(F_c)(C_r) \leq 750$ psi, $C_M = 1.0$

When m.c. $\leq 19\%$ $C_M = 1.0$

Table 2.3.2 Frequently Used Load Duration Factors, C_D^1

Load Duration	C_D	Typical Design Loads
Permanent	0.9	Dead Load
Ten years	1.0	Occupancy Live Load
Two months	1.15	Snow Load
Seven days	1.25	Construction Load
Ten minutes	1.6	Wind/Earthquake Load
Impact ²	2.0	Impact Load

Load duration is based on the live load (CD = 1.0)

CD=1.0

CF=1.0 (assume)

Q11 and 12

CM=1.0 (m.c.=15%)

Q10

Cr=1.15(2x lumber and o.c.=12")

When joist o.c. >24"

Cr=1.0

Analysis Example - HW2

Q8-Q16

Table 1B Section Properties of Standard Dressed (S4S) Sawn Lumber

Nominal Size b x d	Standard Dressed Size (S4S) b x d in. x in.	Area of Section A in. ²	X-X AXIS		Y-Y AXIS		Approximate weight in pounds per linear foot (lbs/ft) of piece when density of wood equals:					
			Section Modulus S _{xx} in. ³	Moment of Inertia I _{xx} in. ⁴	Section Modulus S _{yy} in. ³	Moment of Inertia I _{yy} in. ⁴	25 lbs/ft ³	30 lbs/ft ³	35 lbs/ft ³	40 lbs/ft ³	45 lbs/ft ³	50 lbs/ft ³
Boards¹												
1 x 3	3/4 x 2-1/2	1.875	0.781	0.977	0.234	0.088	0.326	0.391	0.456	0.521	0.586	0.651
1 x 4	3/4 x 3-1/2	2.625	1.531	2.680	0.328	0.123	0.456	0.547	0.638	0.729	0.820	0.911
1 x 6	3/4 x 5-1/2	4.125	3.781	10.40	0.516	0.193	0.716	0.859	1.003	1.146	1.289	1.432
1 x 8	3/4 x 7-1/4	5.438	6.570	23.82	0.680	0.255	0.944	1.133	1.322	1.510	1.699	1.888
1 x 10	3/4 x 9-1/4	6.938	10.70	49.47	0.867	0.325	1.204	1.445	1.686	1.927	2.168	2.409
1 x 12	3/4 x 11-1/4	8.438	15.82	88.99	1.055	0.396	1.465	1.758	2.051	2.344	2.637	2.930
Dimension Lumber (see NDS 4.1.3.2) and Decking (see NDS 4.1.3.5)												
2 x 3	1-1/2 x 2-1/2	3.750	1.56	1.953	0.938	0.703	0.651	0.781	0.911	1.042	1.172	1.302
2 x 4	1-1/2 x 3-1/2	5.250	3.06	5.359	1.313	0.984	0.911	1.094	1.276	1.458	1.641	1.823
2 x 5	1-1/2 x 4-1/2	6.750	5.06	11.39	1.688	1.266	1.172	1.406	1.641	1.875	2.109	2.344
2 x 6	1-1/2 x 5-1/2	8.250	7.56	20.80	2.063	1.547	1.432	1.719	2.005	2.292	2.578	2.865
2 x 8	1-1/2 x 7-1/4	10.88	13.14	47.63	2.719	2.039	1.888	2.266	2.643	3.021	3.398	3.776
2 x 10	1-1/2 x 9-1/4	13.88	21.39	98.93	3.469	2.602	2.409	2.891	3.372	3.854	4.336	4.818
2 x 12	1-1/2 x 11-1/4	16.88	31.64	178.0	4.219	3.164	2.930	3.516	4.102	4.688	5.273	5.859
2 x 14	1-1/2 x 13-1/4	19.88	43.89	290.8	4.969	3.727	3.451	4.141	4.831	5.521	6.211	6.901

Size Factor, C_F

Tabulated bending, tension, and compression parallel to grain design values for dimension lumber 2" to 4" thick shall be multiplied by the following size factors:

Grades	Width (depth)	Size Factors, C _F			
		F _b		F _t	F _c
		Thickness (breadth)			
Select Structural, No.1 & Btr, No.1, No.2, No.3	2", 3", & 4"	1.5	1.5	1.5	1.15
	5"	1.4	1.4	1.4	1.1
	6"	1.3	1.3	1.3	1.1
	8"	1.2	1.3	1.2	1.05
	10"	1.1	1.2	1.1	1.0
	12"	1.0	1.1	1.0	1.0
	14" & wider	0.9	1.0	0.9	0.9
Stud	2", 3", & 4"	1.1	1.1	1.1	1.05
	5" & 6"	1.0	1.0	1.0	1.0
	8" & wider	Use No.3 Grade tabulated design values and size factors			
Construction, Standard	2", 3", & 4"	1.0	1.0	1.0	1.0
Utility	4"	1.0	1.0	1.0	1.0
	2" & 3"	0.4	—	0.4	0.6

In Table 1B Dimension Lumber and Decking, find which two S_x values the required S_x falls between, as shown here 13.14 < S_x = 14.087 < 21.39, so select 2x8 and 2x10.

Q1

$$\text{Try } I_x: F_b' = F_b (C_p C_m C_t C_i C_F C_{fu} C_i C_r)$$

$$= 875 \times 1.15 = 1006.25 \text{ PSI}$$

$$F_v' = F_v (C_p C_m C_t C_i) = 135 \text{ PSI}$$

$$S = \frac{M}{F_b} = \frac{1181.25 \times 12}{1006.25} = 14.087 \text{ in}^3 \text{ (required)}$$

Transfer to inch

From TABLE 1B	S _x
2 x 8	13.14 (C _F =1.2) maybe work
2 x 10	21.39 (C _F =1.1)

Analysis Example - HW2

Q8-Q9, Q13-Q16

Try 2: 2x8, $S_x = 13.14 \text{ in}^3$, $C_F = 1.2$, $A = 10.88 \text{ in}^2$ (From table 1B)

1 1 1 1.2 1 1.15

Q13 $F_b' = F_b (C_D C_M C_t C_i C_F C_{fu} C_i C_r) = 875 \times 1.2 \times 1.15 = 1207.5 \text{ Psi}$

Q14 $F_v' = F_v (C_D C_M C_t C_i) = 135 \text{ Psi}$

Transfer to inch

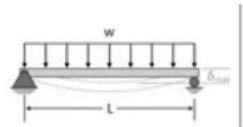
Q15 $f_b = \frac{M}{S_x} = \frac{1181.25 \times 12}{13.14} = 1078.77 < 1207.5 = F_b' \quad \checkmark$

Q16 $f_v = 1.5 \frac{V}{A} = \frac{1.5 \times 315}{10.88} = 43.43 < 135 = F_v' \quad \checkmark$

→ use 2x8 Q8 Depth=8 IN
Q9 CF=1.2

Analysis Example - HW2

Q17-Q20



$$\delta_{max} = \frac{5wL^4}{384EI}$$

Given:

LL=35 PSF

Ct=1.0

Span=15 IN

Ci=1.0

From Table 4A:

E=1400000

Select 2x8

From table 1B

I=47.63 in⁴

17	Factored Allow. Modulus of Elasticity, E'	<input type="text"/>	PSI
18	Short Term Deflection for 100% LL	<input type="text"/>	IN
19	Short Term Deflection Limit for L/360	<input type="text"/>	IN
20	Deflection Passing: enter "1" for pass or "0" for fail	<input type="text"/>	(1 or 0)

CM (Q11,Q12)

L=Span=15 IN

Handwritten calculations on lined paper:

Q17 $E' = E (C_m + C_i) = 1400000 \text{ PSI}$

Q19 $\frac{L}{360} = \frac{15 \times 12}{360} = 0.5 \text{ in}$

$W = LL = 35 \text{ PSF} = 35 \text{ PLF}$ (tributary width = 1 foot)

Q18 $\Delta LL = \frac{5wL^4}{384EI} = \frac{5(35)(15)^4(1728)}{384(1400000)(47.63)} = 0.598 \text{ in}$

Q20 $\Delta LL = 0.598 > \Delta \text{Limit} = \frac{L}{360} = 0.5 \rightarrow \text{Fails}$

Red arrows point from the text "Transfer to inch" to the handwritten calculations for Q17, Q19, and Q18.