ARCH 321 **FINAL EXAM**
(50 pts)

Multiple choice questions are worth 1 point each.

1. Which of the following best describes elasticity?

~~a. it is the greatest stress a material can withstand without rupture~~
b. it is the internal resistance to external forces
c. it is the property of a material that enables it to regain its original shape after removal of its load
~~d. it is the geometric property of a material that indicates its buckling tendencies~~

2. A bottle made of aluminum is sealed with a bronze cap. Unfortunately, during the capping process the top is screwed on too tightly. In order to loosen the cap, would you:

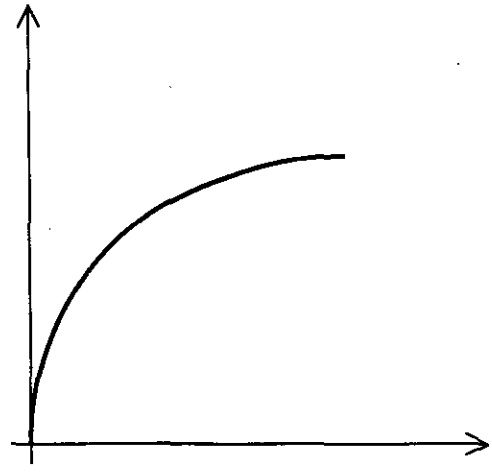
a. place the bottle in your refrigerator or
b. place the bottle under hot running water ?

Bronze = 10×10^{-6}
AL = 12.8×10^{-6}

$\delta = \alpha L \Delta T$

3. The graph in the figure shows the form of the stress-strain behavior for a structural material. Which of the following statements is true for this material

a. ~~the material has a single constant value for~~ its modulus of elasticity
b. ~~the material is ductile~~
c. ~~there is a clearly defined yield point~~
d. stress is not linearly proportional to strain



4. A steel rod 1½" in diameter and 35 feet long stretches 0.252" when subjected to a load. If the modulus of elasticity E is equal to 29,000,000 psi, what is the unit stress in the bar?

a. 21,300 psi
b. 36,000 psi
c. 10,200 psi
d. 17,400 psi

$\delta = \frac{fL}{E}$

$f = \frac{P}{A}$

$.252" = \frac{f(35' \times 12")}{29{,}000{,}000}$

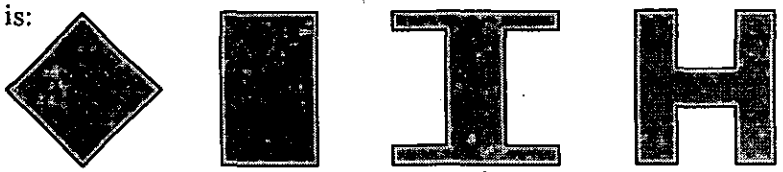
$\frac{7{,}308{,}000}{420} = \frac{f(420)}{420} = 17{,}400$

49/50 very good

3

5. If the beam cross sections shown all have the same depth and total area, the bending efficiency ranked in order from best to worst is:

a. 2, 3, 4, 1
b. 2, 1, 3, 4
c. 3, 2, 4, 1
d 4, 2, 3, 1



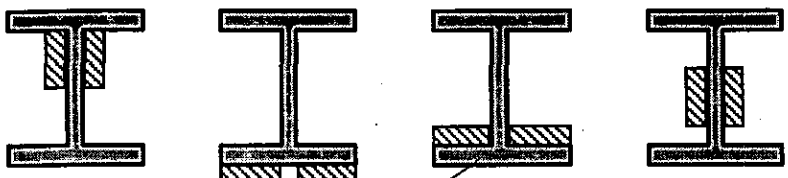
6. Select the correct statement about glued laminated beams.

a. For uniformity and homogeneity, all laminations in a glued laminated beam should be of the same grade.
b. If different lamination grades are used, the higher grade laminations should generally be used at the top and bottom, where the flexural stresses are maximum.
c. Laminations may be of different grades but the allowable stress is based on the lowest grade used.
d. If different lamination grades are used, the higher grade laminations should generally be used near the center of the cross-section where the shear stresses are maximum.

7. The shear stress in a rectangular wood beam (typically) is:

a. maximum at the neutral axis
b. uniform over the beam's cross-section
c. maximum where the moment is zero
d. maximum at mid-span.

8. A wide flange floor beam in a building is required to support a new piece of equipment which will overstress the beam in bending. It is therefore necessary to strengthen the beam. Access is only from below. Which of the methods shown would be most effective, assuming the added plate area(s) are all equal?



9. Select the correct statement(s) about shear stress in a steel beam.

I. The average unit shear stress f_v is equal to $V/t_w d$.

~~II. The shear stress~~ should always be checked for all steel beams because it is generally critical.

III The shear stress should be checked for beams with short spans and a heavy load.

IV The shear stress should be checked for beams with a large concentrated load near a support.

V. If the beam is adequate to resist flexural stress, shear stress is not critical.

~~a. I, II~~

b. I, V

c. I, III, IV

~~d. III, IV~~

10. During the design of a building, the deflection of a beam is calculated to be 1.0". In order to limit the deflection of the beam to 0.75", how should the design be changed?

$\frac{5wL^4}{384EI} = \frac{1}{1.33}$

$\frac{1}{1.25}$ $\frac{1}{1.33}$

~~a. Substitute a beam having a section modulus 25% greater~~

b. Substitute a beam having a moment of inertia 75% greater

c. Substitute a beam having a moment of inertia 25% greater

d. Substitute a beam having a moment of inertia 33.3% greater

11. A sawn timber floor beam spans 24 feet. What is the maximum deflection permitted by the Code for live load only, and for total load.

$\frac{24 \times 12}{360} = .8"$

$\frac{24 \times 12}{240} = 1.2"$

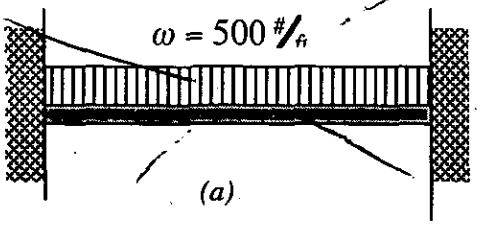
a. 0.73" for live load and 1.10" for total load

b. Deflection is at the designer's discretion

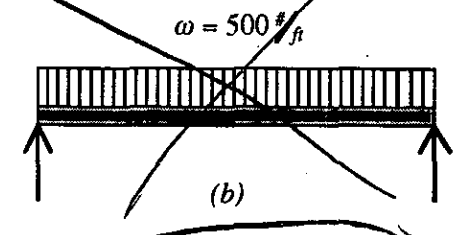
c. 1.20" live load and 1.60" for total load

d. 0.80" for live load and 1.20" for total load

12. Which of the loadings shown will produce the largest deflection? All beams are 24' in length.

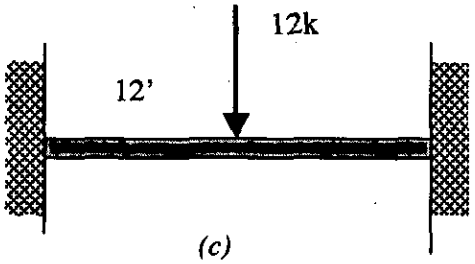


(a)

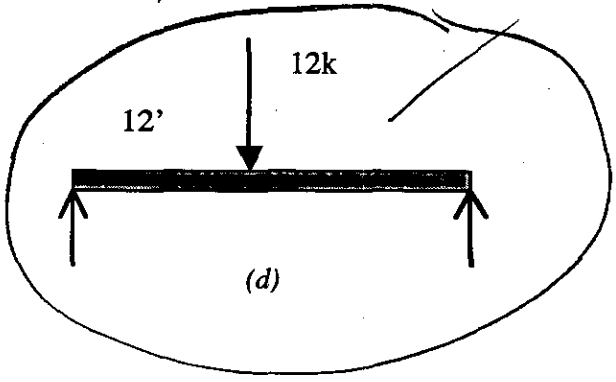


(b)

D.



(c)



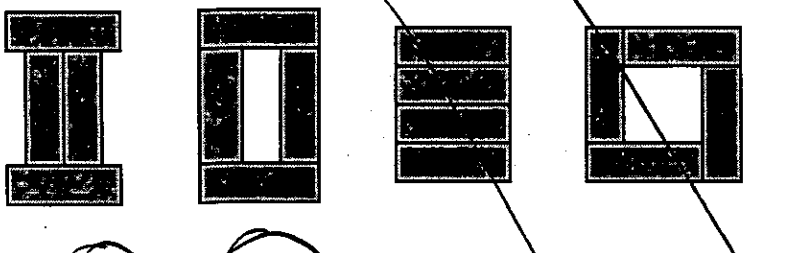
(d)

4

13. For the beams shown in Problem 12, which case results in the smallest deflection?

A. ✓ $\frac{wL^4}{384EI}$

14. Four beam cross-sections are possible using 4-2"x6" sections (full dimensioned) as shown. Determine which cross-section(s) develop(s) the largest moment of inertia I_x. You don't need to calculate the I_x values.



(a) (b) (c) (d)

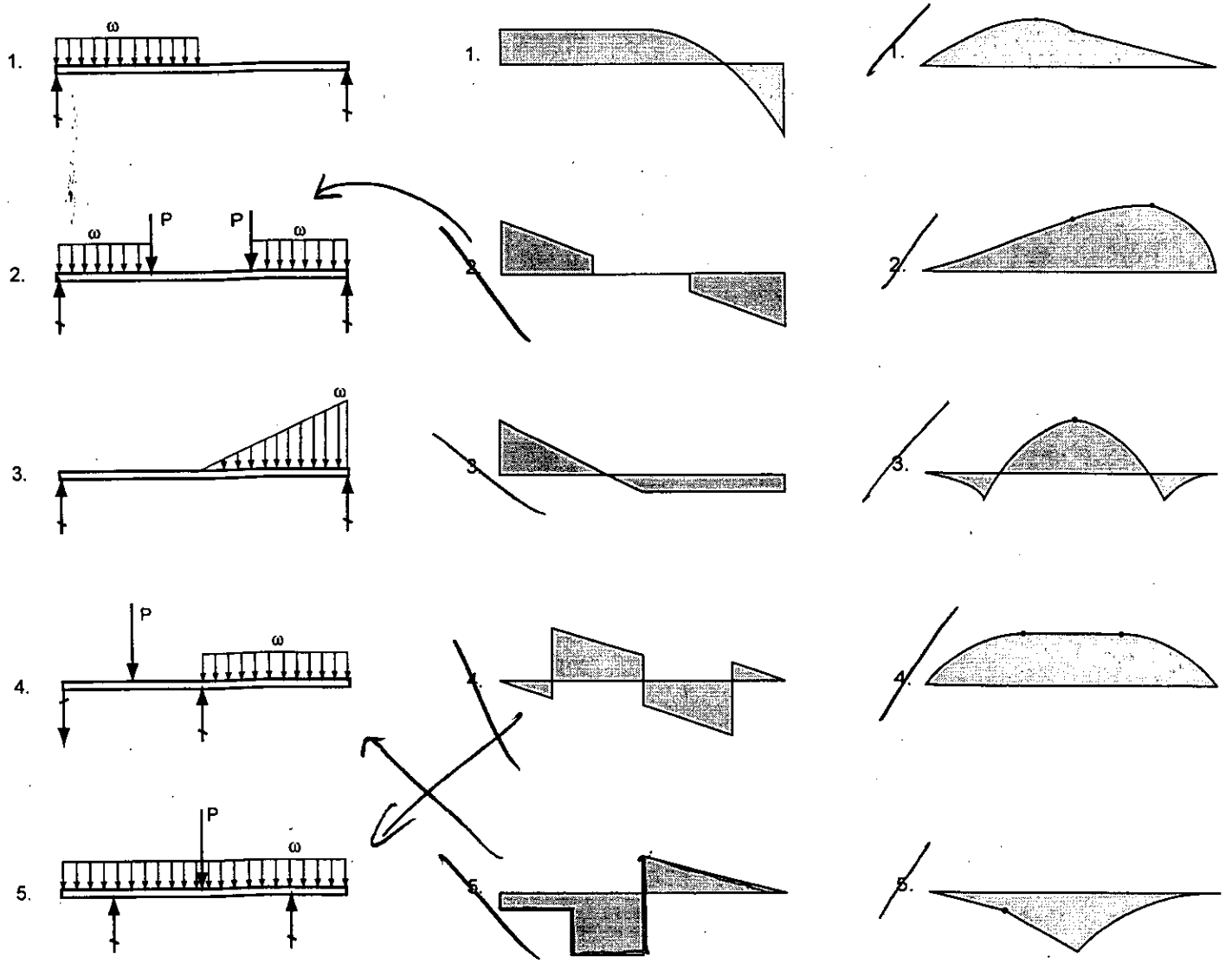
A, B

15. Which beam cross-section has the smallest I_x ?

C ✓ $\frac{bh^3}{12}$

$I_x = I_{xc} + Ad_y^2$

16. (10 pts) Match the appropriate shear (V) and moment (M) diagrams for the load diagrams shown. The shear and moment diagrams are in a scrambled order. Use the table below to record the number of the shear and moment diagram, respectively, that match the load diagram.



Load Diagram	1	2	3	4	5
V Diagram	3	2	1	5	4
M Diagram	1	4	2	5	3

10

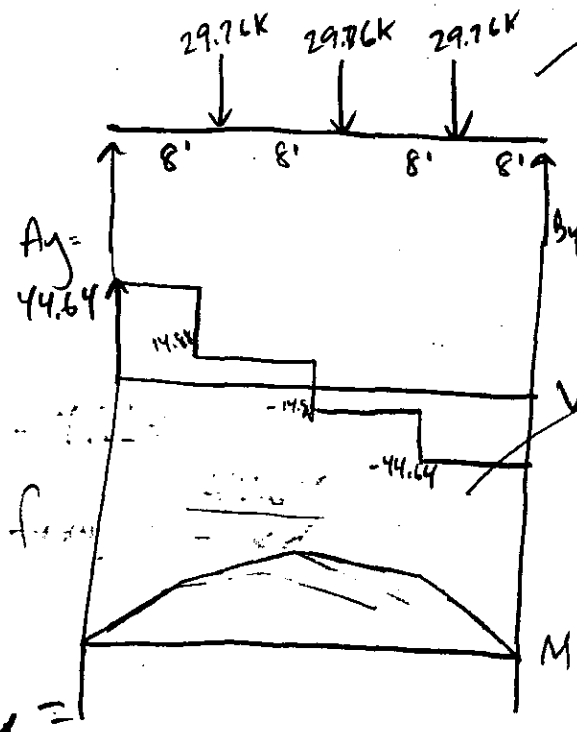
17. (15 pts)
Design of the girder G-2. Select the most economical (lightest) 'W' section.
Check the average web shear and the deflection condition based on DL+LL.

75+80 1240

Beams

$80+75 = 155 \times 8' = 1240\#/ft. = w$

$\frac{wL}{2} = \frac{1240(24)}{2} = 14.88K$



$14.88 \times 2 = 29.76$

$\frac{29.76 \times 3}{2} = Ay, By = 44.64$

$V_{max} = 44.64$

$44.64 \times 8 = 357.12 k\text{-}ft.$

$14.88 \times 8 = 119.04 k\text{-}ft.$

$M_{max} = 476.16 k\text{-}ft$

$M_{max} =$

$f_b = 30 ksi$

$S_{reqd} = \frac{476.16 \times 12}{30 ksi} = 190.46$

lightest = W24×84 ok for Δ and shear.

$S_x = 196$
$I = 2370$
$t_w = .470$
$d = 24.10$

Check for shear

$f_{v\,avg.} = \frac{44.64}{.47 \times 24.10} = 3.94 < 20 ksi$ ok!

15

Check for deflection

3 point load

D2 + LL Allowable = $\frac{L}{240} = \frac{32 \times 12}{240} = 1.6"$

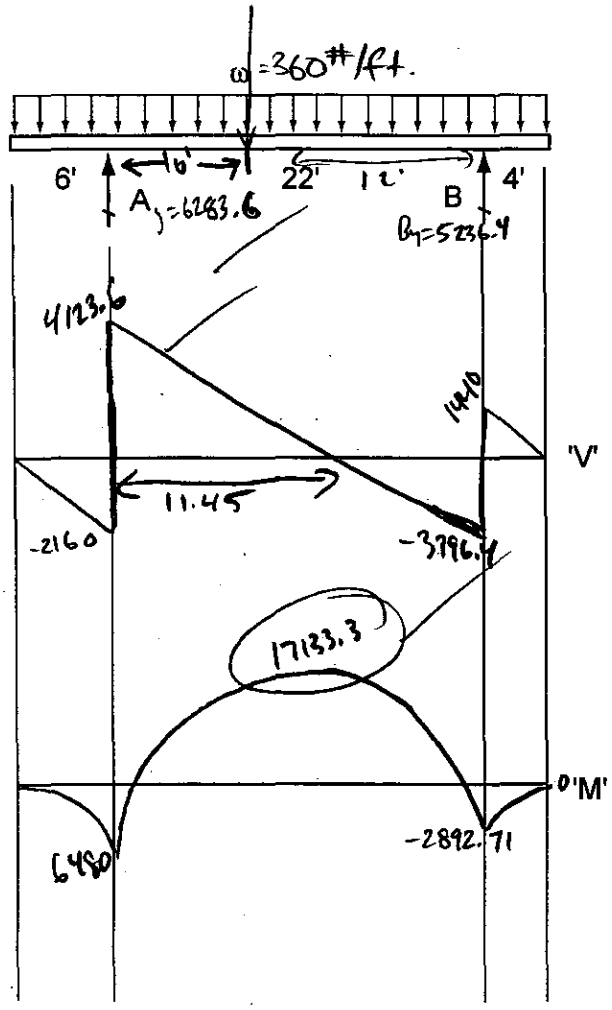
$E = 30 \times 10^3 ksi$

$\Delta_{Deflection\ Actual} = \frac{PL^3}{20.1EI} = \frac{29.76(32)^3 \times 1728}{20.1(30 \times 10^3 ksi)(2370)} = \frac{1685.575}{1429110000} = 1.18" < 1.6"$ ok!

. 18. (10 pts)

c: 6" O.C.

Roof beams are spaced at 6'-0" o.c. and support a snow load of 45 psf. The total roof dead load (including the framing weight) is 15 psf. Assuming glu-lams with an F_b = 2400 psi and F_v = 165 psi, design the most economical $5^1/_8$" width member based on bending and shear. Ignore the deflection requirement.



45 + 15 = 60 psf

60 × 6' = 360#/ft = ω

360 × (22+4+6) = 11520#

$\Sigma MA = \frac{-11520(10')}{22} + \frac{By(22')}{22}$

By = 5236.4

$\Sigma MB = \frac{11520(12')}{22} - Ay(22')$

Ay = 6283.6

Vmax = 4123.6#

Mmax = 17133.3

$S_{req'd} = \frac{17133.3 \times 12"}{2400} = 85.67$

23613.3
− 6480
17133.3

$\Delta V = \omega \Delta x$

$\frac{4123}{760} = \frac{(360)(\Delta x)}{360}$

$\Delta x = \left(\frac{11.45}{\times 4123.6}\right) \frac{1}{2} = 23613.3$

$\frac{1}{2}\left(3796.4 \times (22-11.45)\right)$

= 20,026.01
− 17133.3
−2892.71

$A_{req'd} = \frac{1.5 V_{max}}{F_v}$

$= \frac{1.5(4123.6)}{165}$

$= 37.5 in^2$

Use $5^1/_8 \times 10^1/_2$

$S_x = 94.17$ ok!

$A = 53.81$ ok!

10