Structural Mechanics I

(CE 203)

Exam # 1

by

Dr. Radwam Al-Juruf

C. E. Department

K.F.U.P.M.

King Fahd University of Petroleum & Minerals
DEPARTMENT OF CIVIL ENGINEERING

STRUCTURAL MECHANICS I
(CE 203)

Exam # 1

(Spring, 2005)

Name : Key

ID. No. : ____________________

Use the following data in your solutions whenever needed.

$E = 200$ GPa $\quad\quad$ $E = 30000$ ksi

$\nu = 0.3$

$G = 80$ GPa $\quad\quad$ $G = 12000$ ksi

$\alpha = 6 \times 10^{-6}$ m/m°C

Problem # 1 (30%)

Define the following:

(1) Bearing stress

The stress between two surfaces in contact.

(2) Shear strain

The change in the right angle.

(3) Rupture stress

The stress that will rupture (break) the specimen.

(4) Modulus of Elasticity

The slope of the straight portion of the stress-strain diagram.

(5) Proportional Limit

The last point on the straight portion of the stress-strain diagram.

(6) Poisson's Ratio

Ratio of lateral strain to longitudinal strain.

$$\nu = -\frac{\epsilon_y}{\epsilon_x} = -\frac{\epsilon_z}{\epsilon_x}$$

(7) Coefficient of Thermal Expansion

The change in length of a unit length per degree Centigrade (or fehrenheit)

(8) Hooke's Law

$$\sigma = E \epsilon$$

σ: normal stress
ϵ: " strain
E: Young's Modulus

(9) Isotropic Material

A material whose properties are the same in all directions.

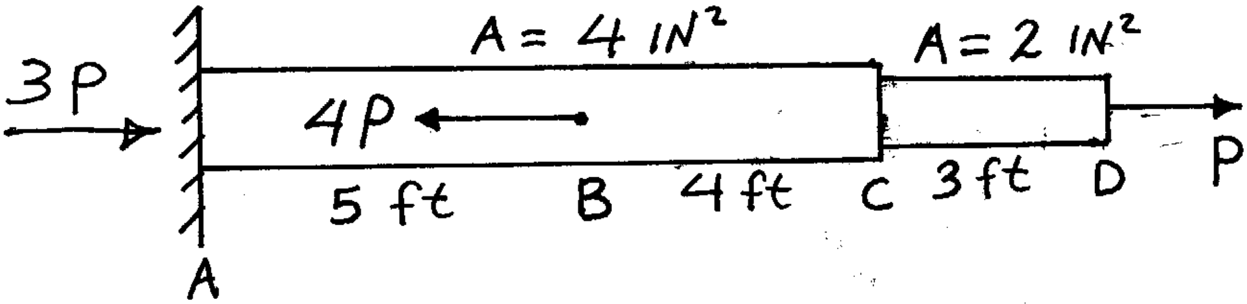
(10) Elastic Limit

The point on the stress-strain diagram up to which the specimen stays elastic.

Problem # 2 (20%)

A stepped bar is subjected to the axial loads shown.

(1) Calculate the maximum value of force P. The allowable normal stress is 24 ksi.



$$\sigma_{allow} = \frac{F}{A}$$

$$\frac{P}{2} = 24 \Rightarrow P = 48^k$$

$$\frac{P}{4} = 24 \Rightarrow P = 96^k$$

$$\frac{3P}{4} = 24 \Rightarrow P = 32^k$$

$$\therefore \max P = 32^k$$

(2) If P = 20 Kips, compute the total change in length of the whole bar.

$$\delta = \Sigma \frac{FL}{AE}$$

$A = 2$
$2A = 4$

$$= \frac{P \times 3}{AE} + \frac{P \times 4}{2AE} - \frac{3P \times 5}{2AE}$$

$$= 1 \times 10^{-3} \text{ ft} + 6.67 \times 10^{-4} \text{ ft} - 2.5 \times 10^{-3} \text{ ft}$$

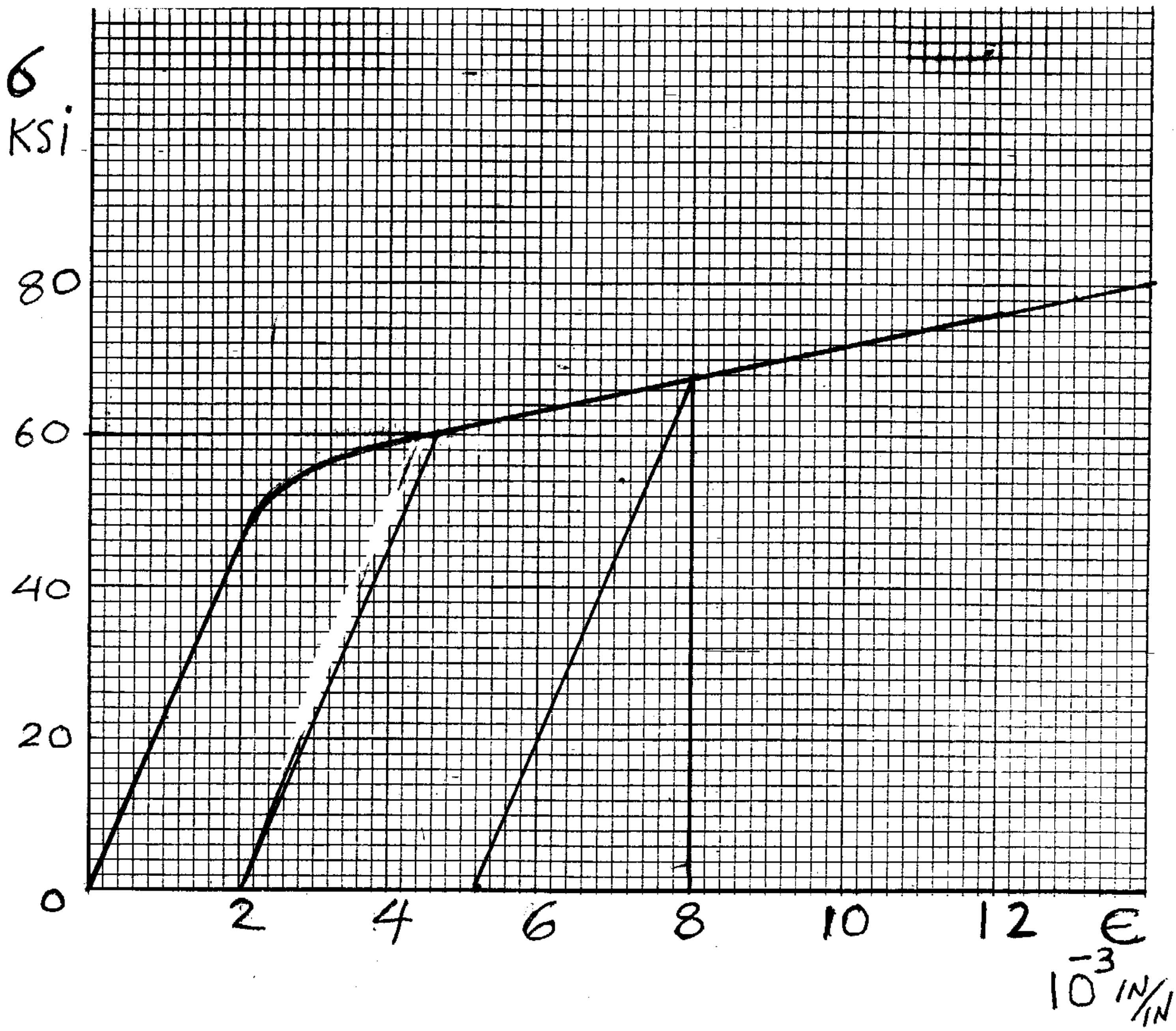
$$\delta = -0.833 \times 10^{-3} \text{ ft}$$

Problem # 3 (30%)

A specimen is tested in tension, and part of its stress-strain diagram is shown below.

Cross section area = 1 in^2

Gage length = 6 in.



(1) What is the load equal to when the strain is 0.001 in/in.

when $\epsilon = 0.001$, $\sigma = 23$ ksi

load $= \sigma A = 1 \times 23 = 23$ K

(2) Obtain Young's Modulus (Modulus of Elasticity).

$$E = \frac{\sigma}{\epsilon} = \frac{46}{.002} = 23000 \text{ ksi}$$

(3) Determine the yield point (yield stress).

Using offset method

at $\epsilon = 0.2\%$

$\sigma = 60$ ksi

(4) Compute the new length of the specimen if the machine is stopped when the strain reading is 0.008 in/in then the load is removed.

$\epsilon = 0.0052$

$\delta = \epsilon L = 0.0052 \times 6$

$= 0.0312$

$L = L_o + \delta = 6.0312$ IN

(5) Calculate the percent elongation of the specimen when the strain is equal to 0.3 in/in.

$\delta = \epsilon L = 0.3 \times 6 = 1.8$ IN

$\%$ elongation $= \frac{1.8}{6} = 30\%$

(6) Determine the change in diameter when the stress is 78 ksi.

$$\frac{\pi d^4}{4} = A = 1 \text{ IN}^2$$

$$\therefore d = 1.06$$

when $\sigma = 78$ ksi
$\epsilon = 12.8 \times 10^{-3}$

$$\delta_d = \epsilon_d d$$

$$\epsilon_d = \nu \epsilon_\ell = 0.3 \times 0.0128$$

$$= 38.4 \times 10^{-4}$$

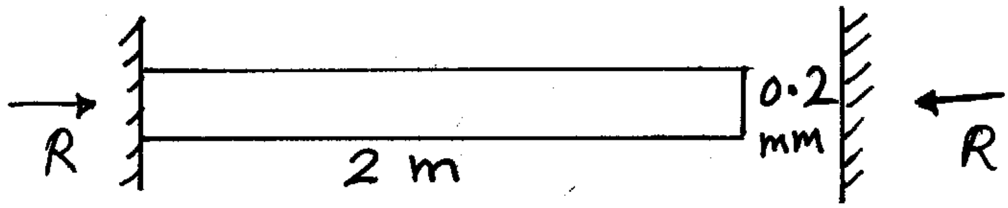
$$\therefore \delta_d = 38.4 \times 10^{-4} \times 1.06$$

$$= 4.07 \times 10^{-3} \text{ IN}$$

(10)

Problem # 4 (20%)

A beam was constructed between two rigid walls with a right gap equal to 0.2 mm. If the temperature increases, calculate the temperature increase. The allowable normal stress is 160 MPa.



$$\delta_T + \delta = 0.2 \times 10^{-3} \text{ m}$$

$$\alpha \Delta T L - \frac{RL}{AE} = 0.2 \times 10^{-3}$$

$$\alpha \Delta T L - \frac{\sigma L}{E} = 0.2 \times 10^{-3}$$

$$6 \times \Delta T \times 2 - \frac{160 \times 10^{6} \times 2}{200 \times 10^{9}} = 0.2 \times 10^{-3}$$

$$12 \times 10^{-6} \Delta T - 1.6 \times 10^{-3} = 0.2 \times 10^{-3}$$

$$12 \times 10^{-6} \Delta T = 1.8 \times 10^{-3}$$

$$\Delta T = 150\ ^\circ C$$