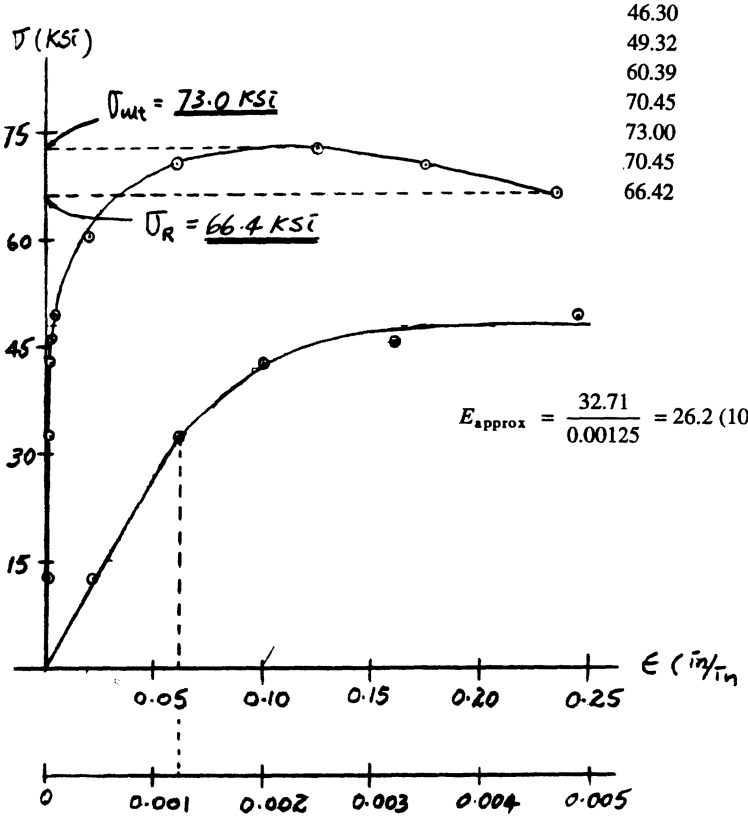
3–1 A tension test was performed on a steel specimen having an original diameter of 0.503 in. and a gauge length of 2.00 in. The data is listed in the table. Plot the stress–strain diagram and determine approximately the modulus of elasticity, the ultimate stress, and the rupture stress. Use a scale of 1 in. = 15 ksi and 1 in. = 0.05 in./in. Redraw the linear-elastic region, using the same stress scale but a strain scale of 1 in. = 0.001 in.

Load (kip)	Elongation (in.)
0	0
2.50	0.0009
6.50	0.0025
8.50	0.0040
9.20	0.0065
9.80	0.0098
12.0	0.0400
14.0	0.1200
14.5	0.2500
14.0	0.3500
13.2	0.4700

$A = \frac{1}{4}\pi(0.503)^2 = 0.19871 \text{ in}^2$

$L = 2.00$ in.

$\sigma = \frac{P}{A}$ (ksi)	$\varepsilon = \frac{\Delta L}{L}$ (in./in.)
0	0
12.58	0.00045
32.71	0.00125
42.78	0.0020
46.30	0.00325
49.32	0.0049
60.39	0.02
70.45	0.06
73.00	0.125
70.45	0.175
66.42	0.235



$$E_{approx} = \frac{32.71}{0.00125} = 26.2\,(10^3) \text{ ksi}$$ **Ans**

3–2 A tension test was performed on a steel specimen having an original diameter of 0.503 in. and gauge length of 2.00 in. Using the data listed in the table, plot the stress–strain diagram and determine approximately the modulus of toughness.

Load (kip)	Elongation (in.)
0	0
2.50	0.0009
6.50	0.0025
8.50	0.0040
9.20	0.0065
9.80	0.0098
12.0	0.0400
14.0	0.1200
14.5	0.2500
14.0	0.3500
13.2	0.4700

Modulus of toughness (approx)

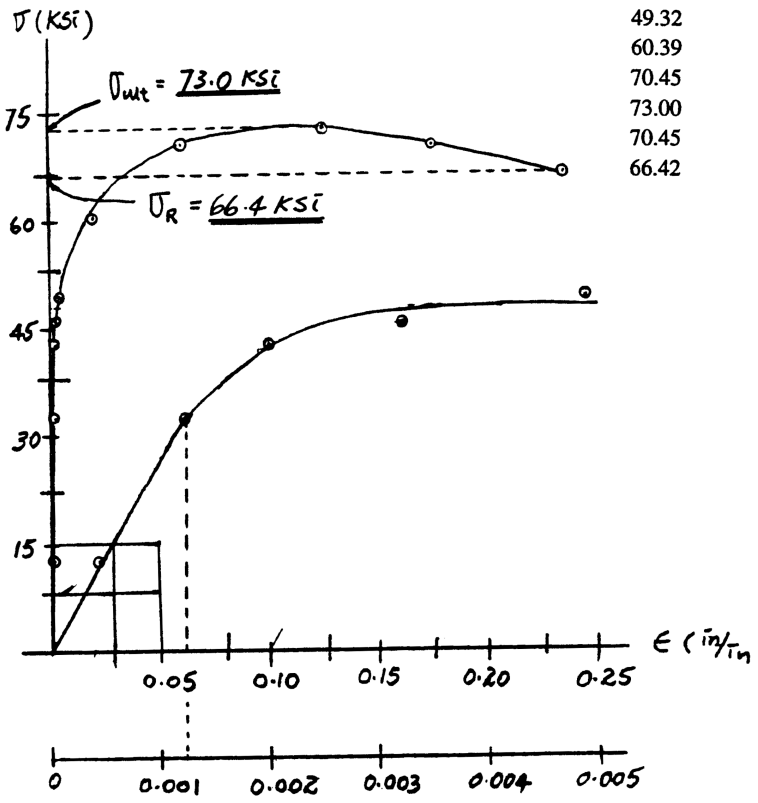
u_t = total area under the curve

= 87 (7.5) (0.025) (1)

$$= 16.3 \frac{\text{in.} \cdot \text{kip}}{\text{in}^3} \quad \textbf{Ans}$$

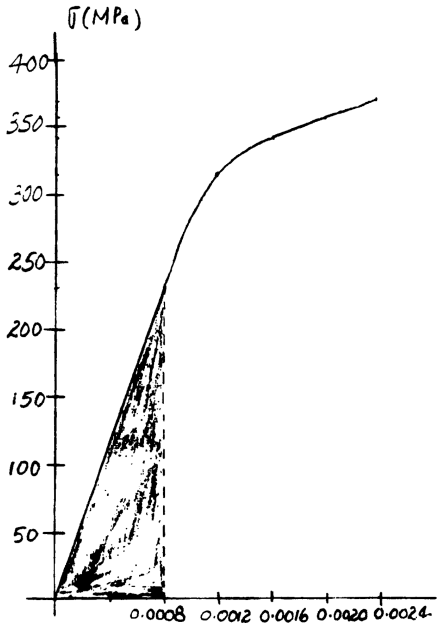
In Eq.(1), 87 is the number of squares under the curve.

$\sigma = \frac{P}{A}$ (ksi)	$\varepsilon = \frac{\Delta L}{L}$ (in./in.)
0	0
12.58	0.00045
32.71	0.00125
42.78	0.0020
46.30	0.00325
49.32	0.0049
60.39	0.02
70.45	0.06
73.00	0.125
70.45	0.175
66.42	0.235



3–3 Data taken from a stress–strain test for a ceramic is given in the table. The curve is linear between the origin and the first point. Plot the curve, and determine the modulus of elasticity and the modulus of resilience.

σ (MPa)	ε (mm/mm)
0	0
229	0.0008
314	0.0012
341	0.0016
355	0.0020
368	0.0024



$$E = \frac{229(10^6)}{0.0008} = 286\,\text{GPa} \qquad \textbf{Ans}$$

$$u_r = \frac{1}{2}(229)(10^6)\,\text{N/m}^2(0.0008)\,\text{mm/mm}$$

$$= 91.6\,\text{kJ/m}^3 \qquad \textbf{Ans}$$

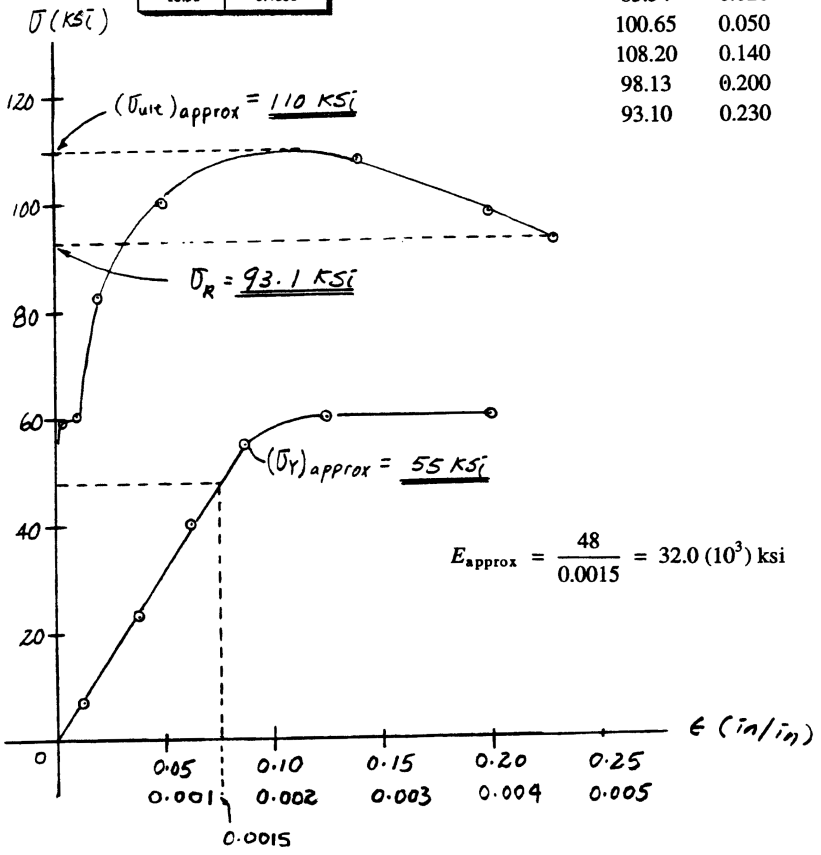
***3–4** A tension test was performed on a steel specimen having an original diameter of 0.503 in. and gauge length of 2.00 in. The data is listed in the table. Plot the stress–strain diagram and determine approximately the modulus of elasticity, the yield stress, the ultimate stress, and the rupture stress. Use a scale of 1 in. = 20 ksi and 1 in. = 0.05 in./in. Redraw the elastic region, using the same stress scale but a strain scale of 1 in. = 0.001 in./in.

Load (kip)	Elongation (in.)
0	0
1.50	0.0005
4.60	0.0015
8.00	0.0025
11.00	0.0035
11.80	0.0050
11.80	0.0080
12.00	0.0200
16.60	0.0400
20.00	0.1000
21.50	0.2800
19.50	0.4000
18.50	0.4600

$A = \frac{1}{4}\pi(0.503)^2 = 0.1987 \text{ in}^2$

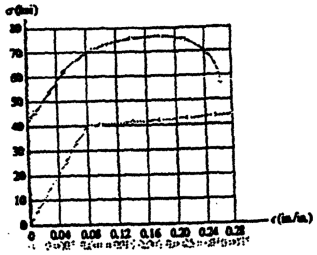
$L = 2.00$ in.

σ(ksi)	ε(in./in.)
0	0
7.55	0.00025
23.15	0.00075
40.26	0.00125
55.36	0.00175
59.38	0.0025
59.38	0.0040
60.39	0.010
83.54	0.020
100.65	0.050
108.20	0.140
98.13	0.200
93.10	0.230



$$E_{approx} = \frac{48}{0.0015} = 32.0\,(10^3) \text{ ksi}$$ **Ans**

3-5. The stress–strain diagram for a steel alloy having an original diameter of 0.5 in. and a gauge length of 2 in. is given in the figure. Determine approximately the modulus of elasticity for the material, the load on the specimen that causes yielding, and the ultimate load the specimen will support.



Modulus of Elasticity : From the stress – strain diagram, $\sigma = 40$ ksi when $\varepsilon = 0.001$ in./in.

$$E_{approx} = \frac{40-0}{0.001-0} = 40.0\left(10^3\right) \text{ ksi} \qquad \textbf{Ans}$$

Yield Load : From the stress – strain diagram, $\sigma_Y = 40.0$ ksi.

$$P_Y = \sigma_Y A = 40.0\left[\left(\frac{\pi}{4}\right)\left(0.5^2\right)\right] = 7.85 \text{ kip} \qquad \textbf{Ans}$$

Ultimate Load : From the stress – strain diagram, $\sigma_u = 76.25$ ksi.

$$P_u = \sigma_u A = 76.25\left[\left(\frac{\pi}{4}\right)\left(0.5^2\right)\right] = 15.0 \text{ kip} \qquad \textbf{Ans}$$