Homework 6.0

Carefully review chapter 6 lecture slides and, if time allows, read textbook sections (Askeland 6.1-6.7, 6.9-6.10) and give an honor statement confirming the reading

Homework 6.1

A cylindrical alloy sample having an elastic modulus of 100 GPa and an original diameter of 4 mm will experience only elastic deformation when a tensile force of 2000 N is applied. If the maximum allowable elongation is 0.4 mm, compute the maximum length of the specimen before deformation (application of the tensile force)

Normal engineering stress due to tensile force in the sample:

$$\sigma = \frac{F}{A} = \frac{?}{??} = 1.592 \times 10^8 \; Pa \;\; \text{or} \;\; 159.2 \; MPa$$

Since elastic deformation, engineering strain can be obtained from Hooke's Law

$$\epsilon = \frac{\sigma}{E} = \frac{?}{??} = 0.001592$$

Absolute change in length must satisfy: $\Delta L = \epsilon L_0 \leq ? \, mm$

Initial length must satisfy: $L_0 \leq \frac{?}{??} = \cdots = \mathbf{0.251 \, m}$ or 25.1 cm

Homework 6.2 (1)

A tensile load of 25000N is applied to a cylindrical rod of 400 mm long and a radius of 5 mm. If the rod should not experience plastic deformation and the absolute elongation should not be more than 1 mm, which of the material below are possible candidates and why?

Material	E **(10^9 Pa)**	σ_y **(10^6 Pa)**	σ_U **(10^6 Pa)**
Aluminum alloy	70	255	420
Copper alloy	100	345	420
Pure copper	100	250	290
Steel alloy	207	450	550

Homework 6.2 (2)

Normal engineering stress due to tensile force in the sample:

$$\sigma = \frac{F}{A} = \frac{?}{??} = 3.18 \times 10^{8}\ Pa \ \text{ or } \ 318\ MPa$$

Requirement of NO plastic deformation, means the material's yield strength must be … than calculated normal engineering stress of ...

Therefore, both **steel** and **copper** alloy meet the requirement from yield strength point of view

On the other hand, absolute change in length must also satisfy $\Delta L = \epsilon L_0 \le \cdots$

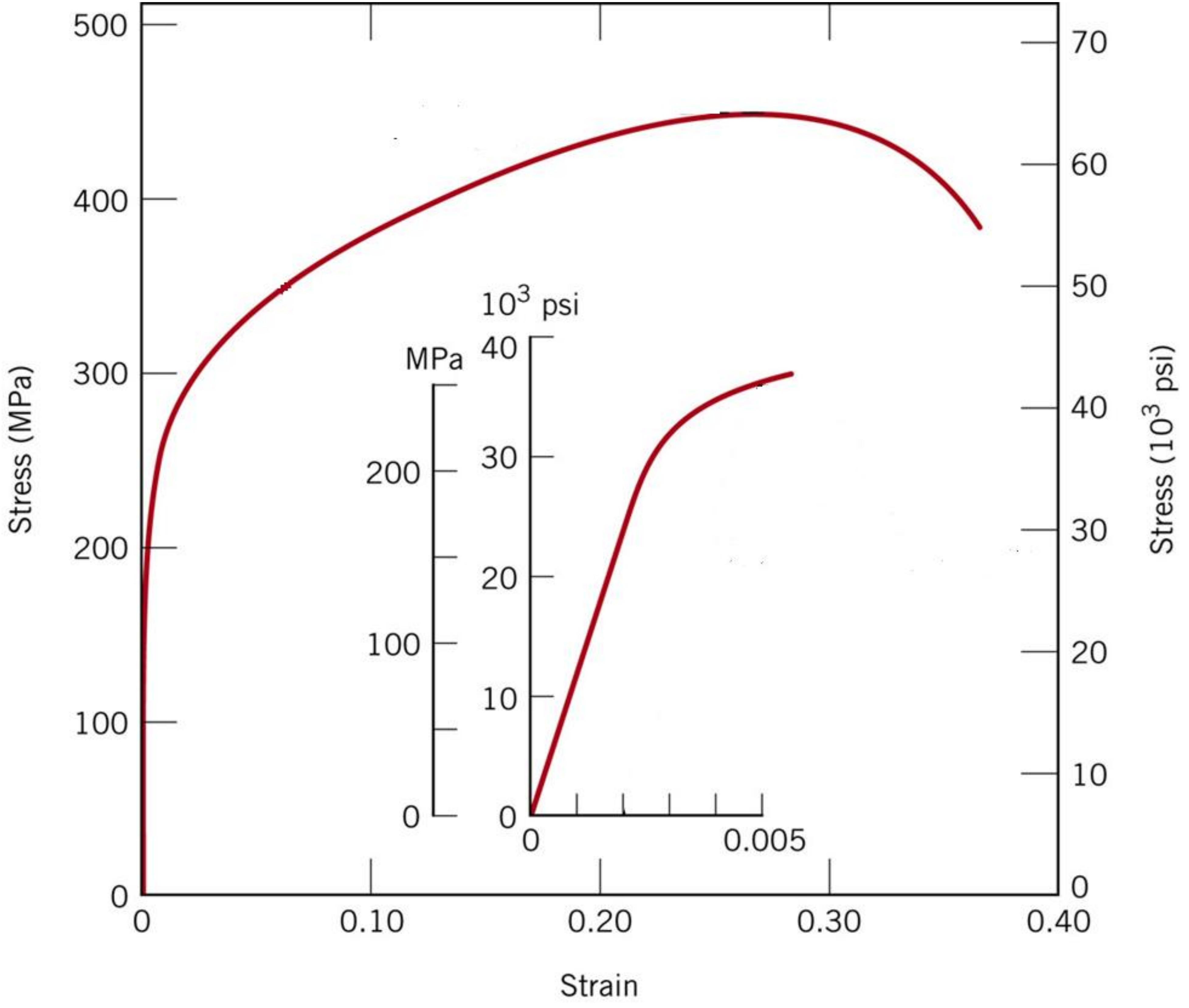
For the given steel alloy with elastic modulus of … GPa, the absolute change in length will be

$$\Delta L(steel\ alloy) = \epsilon L_0 = \frac{\sigma}{E} L_0 = \frac{?}{??} \times ??? = 0.615\ mm < 1\ mm$$

For the given copper alloy with elastic modulus of … GPa, the absolute change in length will be

$$\Delta L(copper\ alloy) = \epsilon L_0 = \frac{\sigma}{E} L_0 = \frac{?}{??} \times ??? = 1.27\ mm > 1\ mm$$

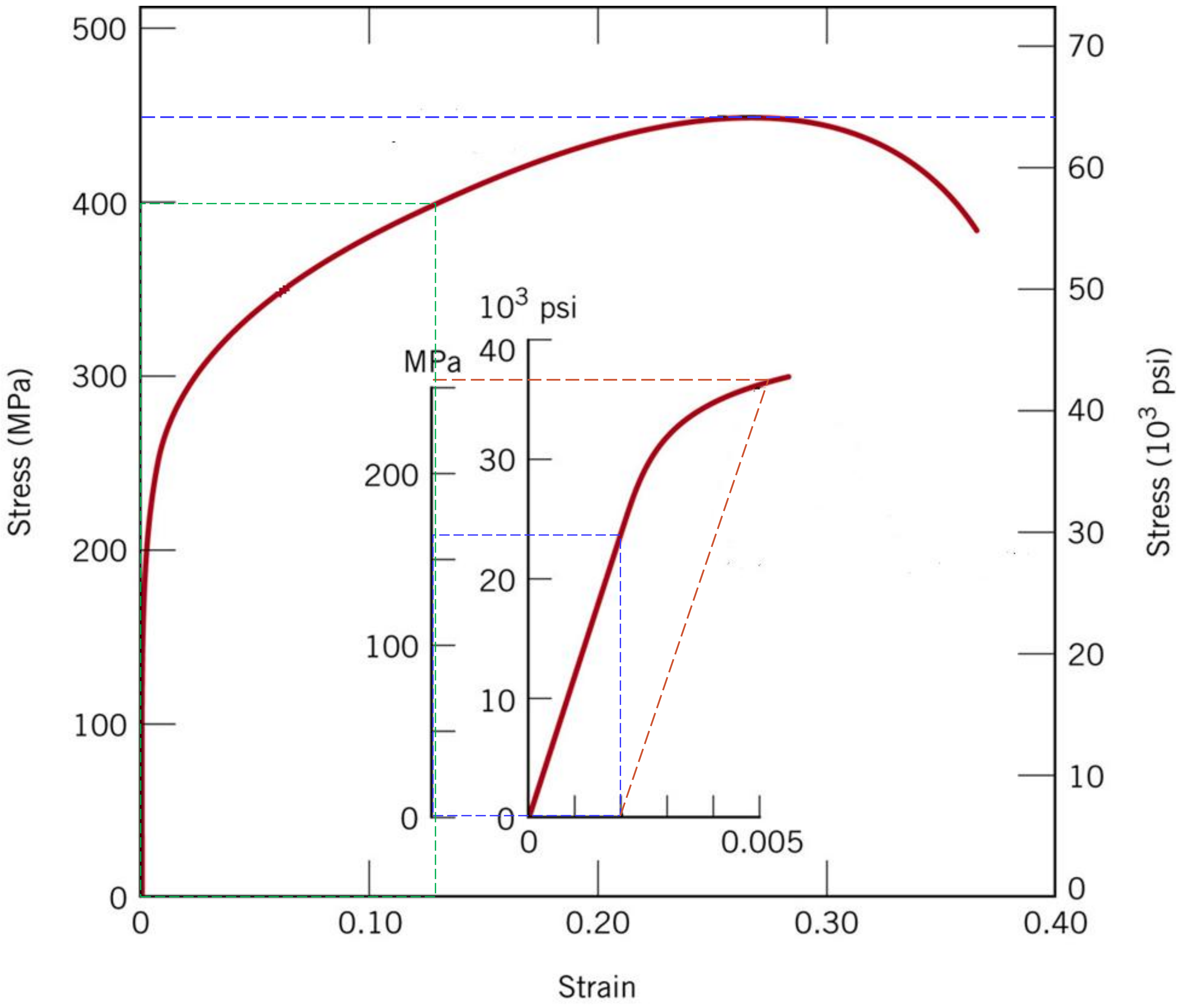
Therefore, **the <u>steel</u> alloy listed in the table satisfies <u>both</u> requirements**.



Homework 6.3 (1)

Based on the tensile engineering stress – strain curve for copper alloy (insert is zoom-in for the low stress region), determine (i) Elastic modulus; (ii) Offset yield strength and ultimate tensile strength; (iii) Maximum load by a cylinder specimen with original diameter of 10 mm; (d) Change in length for a 200 mm sample subject to 400 MPa

Homework 6.3 (2)



(1) Elastic modulus is estimated from the slope of the initial linear section (see the blue rectangle)

$$E = \frac{\Delta\sigma}{\Delta\epsilon} \approx \frac{?}{??} = 81\ GPa$$

(2) Offset yield strength for strain of 0.2% (or 0.002) is estimated to be

$\sigma_Y \approx 250\ MPa\ or\ 37 \times 10^3\ psi$

Tensile strength is estimated to be

$\sigma_U \approx 450\ MPa\ or\ 64 \times 10^3 psi$

(3) Max load for a 10 mm dia. sample:

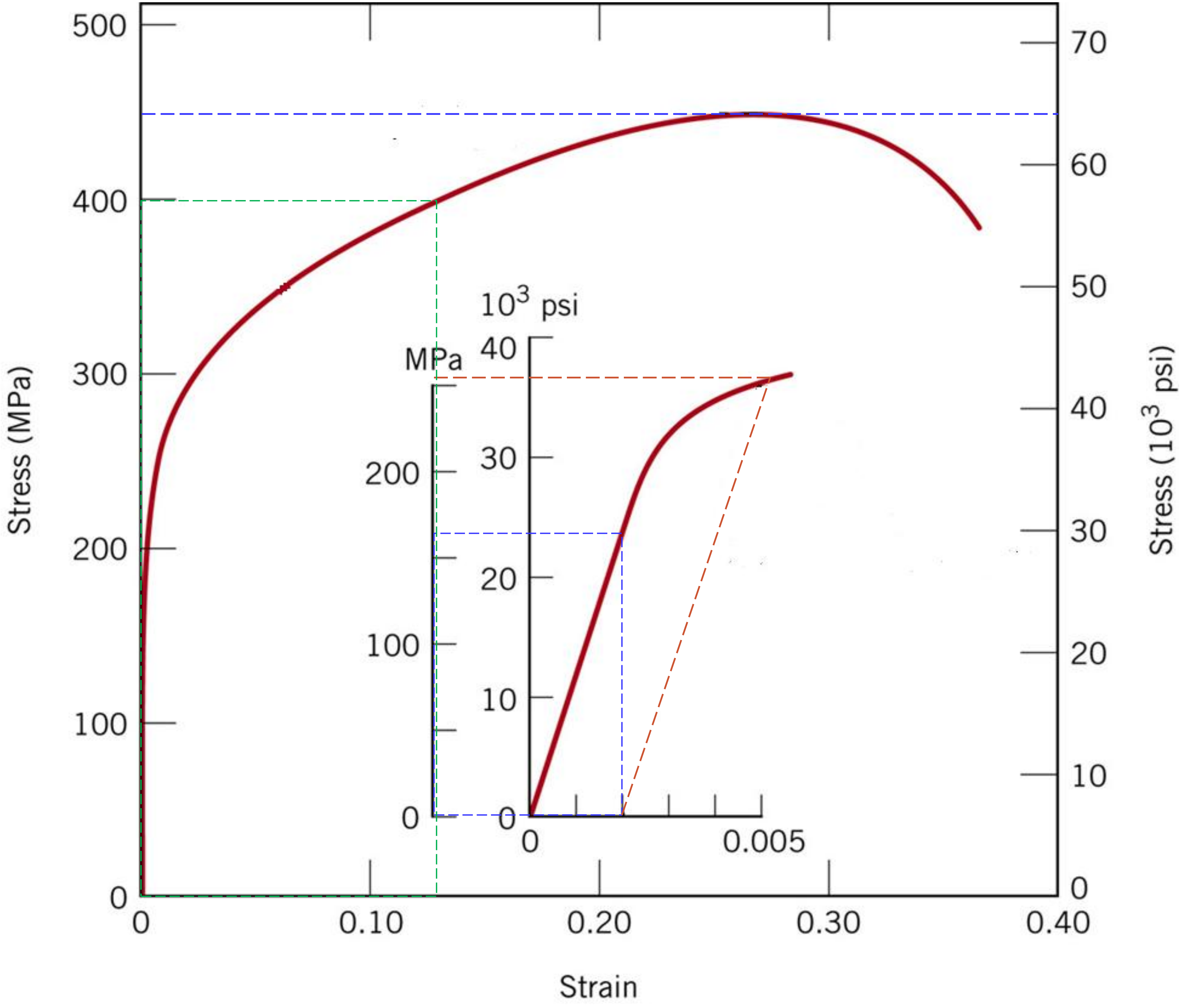
$$P_{max} = \sigma_{max}\ A$$

$$\approx ? \times ?? \times ???$$

$$= \mathbf{35.3 \times 10^3 N}$$

When reaching such a load, the sample will (almost certainly) fail or fracture

Homework 6.3 (3)



4) 400 MPa is in the non-linear, plastic deformation region. Corresponding strain (see green line)

$$\epsilon \approx 0.125$$

$$\Delta L = \epsilon L_0 = ? \times ??$$

$$= 0.025\, m \text{ or } \mathbf{25\, mm}$$

Homework 6.4 (1)

A cylindrical specimen with a diameter of 12.8 mm and a gauge length of 50.800 mm is pulled in tension. `Based on the tensile data on the right:

(1) Plot the tensile curve (i.e., engineering stress vs. engineering strain)

(2) Compute the modulus of elasticity

(3) Determine the yield strength at a strain offset of 0.002

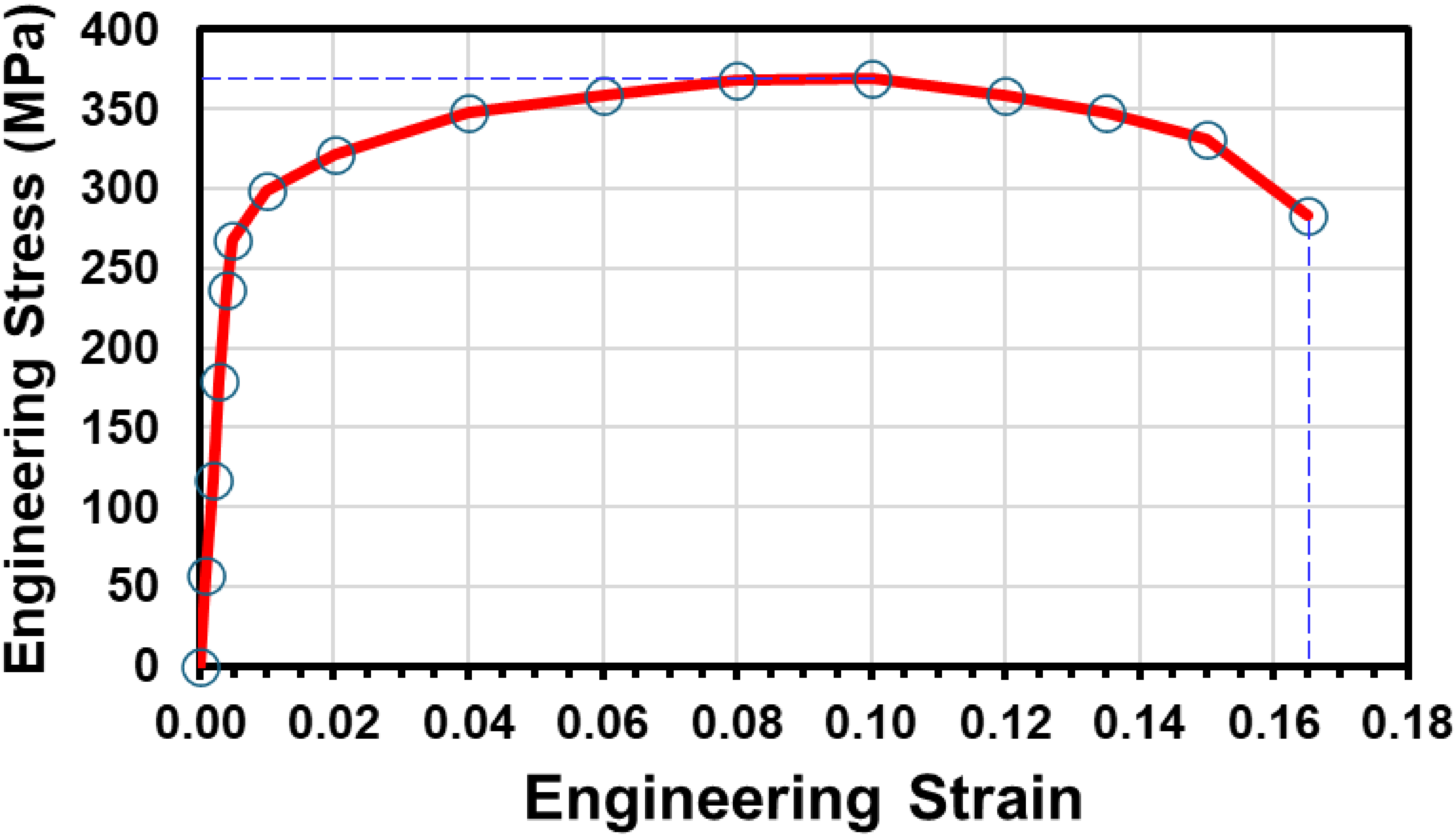
(4) Determine the tensile strength of this alloy

(5) What is the approximate ductility, in percent elongation?

Force (kN)	Guage Length (mm)
0.00	50.80
7.33	50.85
15.10	50.90
23.10	50.95
30.40	51.00
34.40	51.05
38.40	51.31
41.30	51.82
44.80	52.83
46.20	53.85
47.30	54.86
47.50	55.88
46.10	56.90
44.80	57.66
42.60	58.42
36.40	59.18

Homework 6.4 (2)

(1) Tensile curve



Homework 6.4 (2)

(2) Modulus of elasticity through fitting of the stress-strain curve up to 236 MPa

$$\boldsymbol{E = 60.5\ GPa}$$

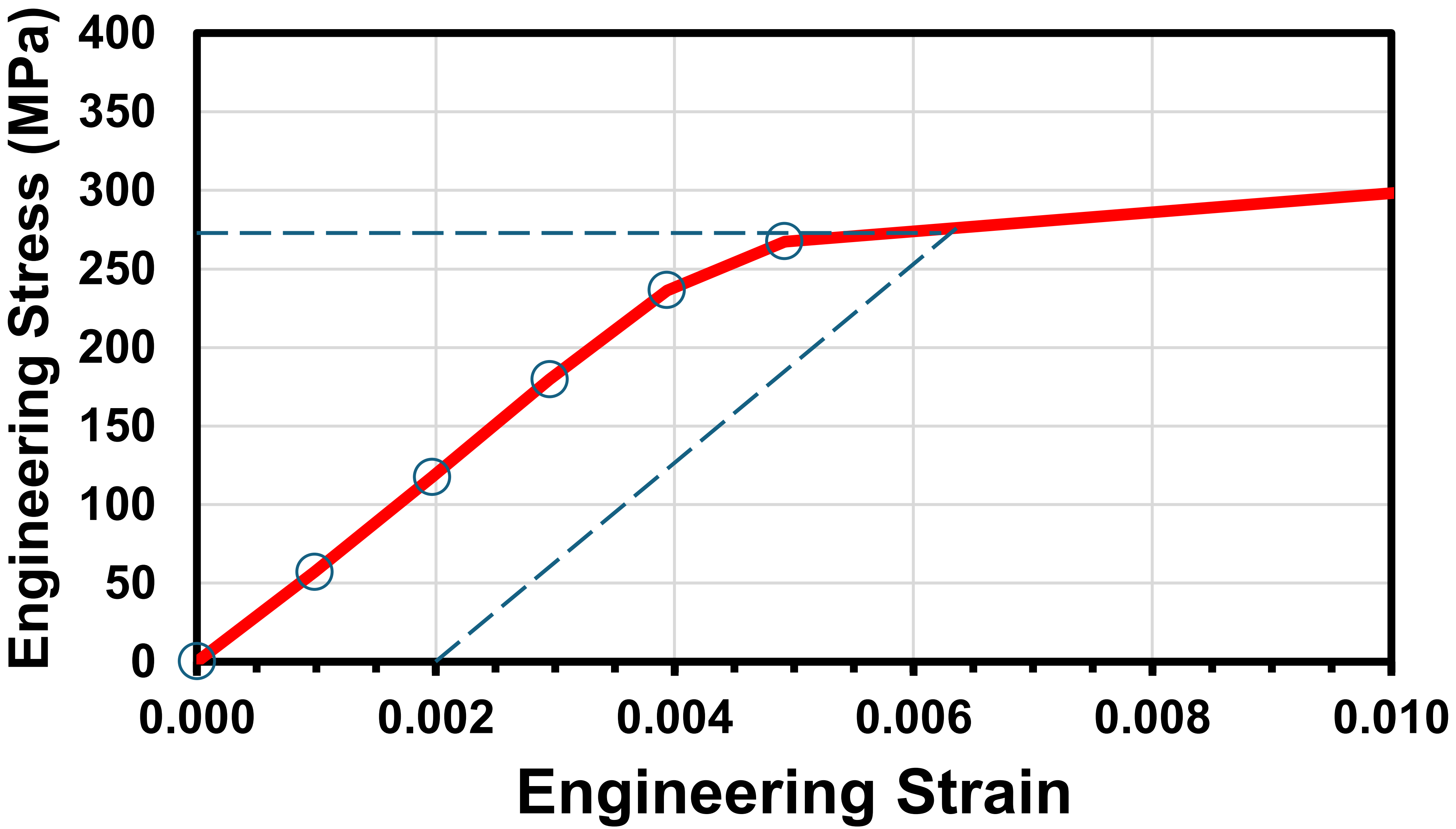
or, simply estimate from zoom-in of graph:

$$E = \frac{\Delta\sigma}{\Delta\epsilon} = \sim \frac{120MPa - 0}{0.002 - 0} = 60GPa$$

(3) Off-set yield strength for 0.2% elastic strain limit

$$\boldsymbol{\sigma_Y \approx 275\ MPa}$$

From (0 stress, 0.002 strain) point, draw a parallel line to tensile curve, find intercept w/ tensile curve, read vertical or stress coordinate



(4) Tensile strength

$\boldsymbol{\sigma_U \approx 370\ MPa}$ ← The highest point for the entire tensile or engineering stress-strain curve (see previous page)

(5) Ductility

$\boldsymbol{\%EL \approx 16.5\%\ \text{or}\ 0.165}$ ← The greatest strain for the entire tensile or engineering stress-strain curve, before fracture/failure (see previous page)