ERRATA for
PE Mechanical Engineering: Machine Design and Materials Practice Exam

ISBN: 978-1-947801-01-1

Errata posted 11/23/2022

Revisions are shown in red.

Question 8, p. 13
An initial analysis of the critical speed of the cylindrical, steel lead screw for a proposed linear positioning system is to be performed using the equation given below.

$$\text{Critical speed (rad/s)} = \frac{215}{L^2}\sqrt{\frac{g_c EI}{\rho A}}$$

where:

- L = length of lead screw
- E = modulus of elasticity
- I = area moment of inertia
- ρ = density
- A = cross-sectional area
- ~~g = acceleration of gravity~~

Other Data:

Length of lead screw	48 in.
Root diameter of lead screw	0.84 in.
Young's modulus of steel	30,000,000 psi
Density of steel	490 lb/ft^3
g_c	386 in./s^2

The critical speed (rad/s) of the lead screw is most nearly:

- ○ A. 1,150
- ○ B. 3,950
- ○ C. 91,250
- ○ D. 190,000

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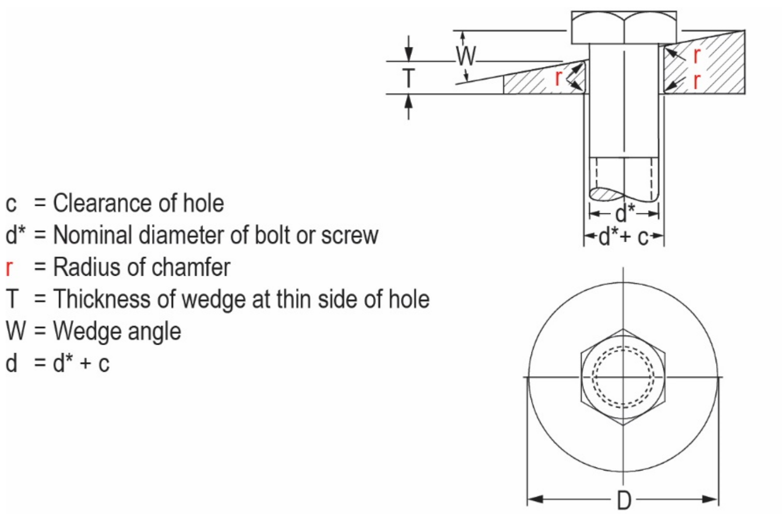
Question 28, p. 26
The second line should read:

If this is used in an application where the vertical load is 1,000 lb, the shear stress (psi) in the adhesive would be most nearly:

Question 36, p. 30



Question 56, p. 41
The first line should read:

A machine element 10 m long with a cross section 100 mm × 150 mm is loaded in compression as shown in the top figure.

Question 62, p. 44
A single-row ball bearing is subjected to a radial load of 75 lb (with no axial load), has a catalog-rated life of 180,000 min, and a catalog-rated speed of 500 rpm. The radial load (lb) of the bearing when rotating at 10 rad/sec with a design life of 268,000 min is most nearly:

○ A. 264
○ B. 114
○ C. 90
○ D. 66

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Question 73, p. 50

○ A. 1.11

○ B. 1.25

○ C. 1.57

○ D. 2.22

Solution Table, p. 58
28: C
56: C
71: B
73: B

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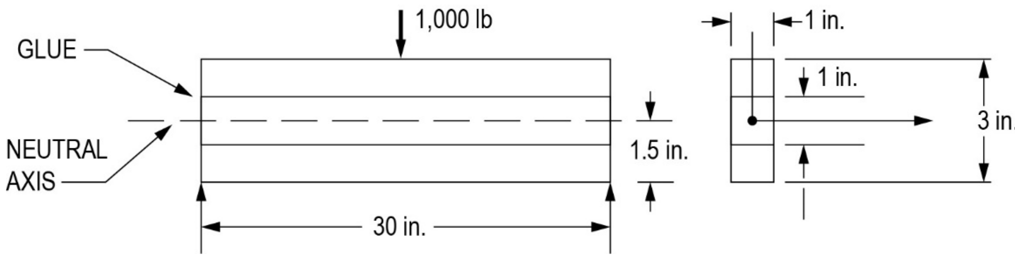
Solution 28, p. 72

$$\tau = \frac{VQ}{It}$$

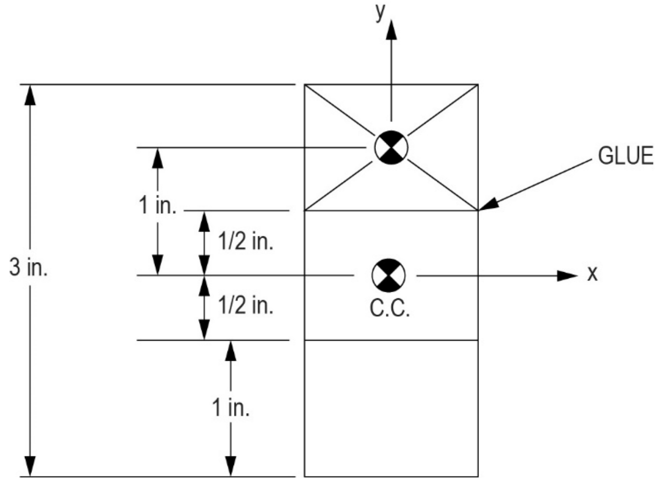


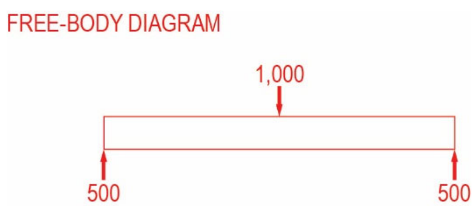
$$I = \frac{bH^3}{12} = \frac{(1)(3)^3}{12} = 2.25\ \text{in}^4$$

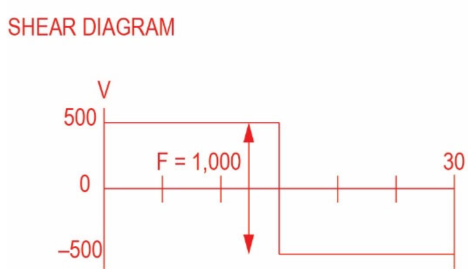
t = 1 in. wide

Q (first moment of inertia) at location of shear stress

= 1 × 1 × 1 = 1







$$\tau = \frac{VQ}{It}$$

$$= \frac{(500\ \text{lb})(1\ \text{in}^3)}{(2.25\ \text{in}^4)(1\ \text{in.})} = 222\ \text{lb/in}^2$$

THE CORRECT ANSWER IS: C

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Solution 31, p. 74

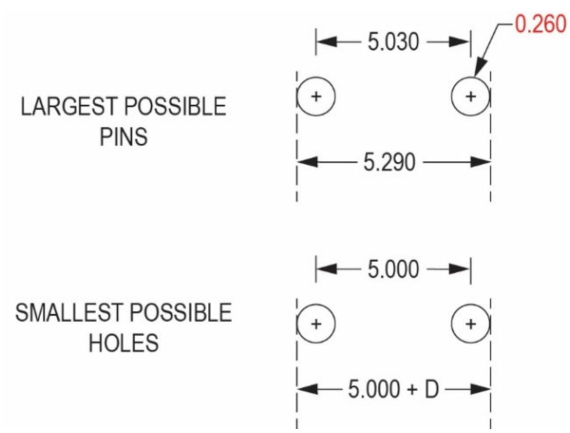
Grade 5 rod has a yield of 81,000 lb/in^2

For a 1 1/4-7 thread the tensile stress area is 0.969 in^2. A factor of safety of 4 is required.

$$\left(\frac{P}{0.969}\right)=\left(\frac{81,000\ \text{lb/in}^2}{4}\right)\Rightarrow P=\left(0.969\ \text{in}^2\right)\left(\frac{81,000\ \text{lb/in}^2}{4}\right)$$

$$P = 19,622\ \text{lb}$$

Solution 37, p. 77



5.290 = 5.000 + D

D = 0.290

Solution 42, p. 78

The last line should read:

$$|v_C| = \frac{5}{2} = 2.5\ \text{m/s}$$

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Solution 56, p. 85

Check to see if column is "slender":

Calculate radius of gyration

$$r = \frac{0.1\ \text{m}}{2\sqrt{3}} = 0.029\ \text{m}$$

Verify L/r > 100 to make sure "slender" column assumption is valid even if the length is halved by the addition of intermediate supports.

$$\frac{L}{r} = \frac{5\ \text{m}}{0.029\ \text{m}} = 172 \qquad \text{OK}$$

Check buckling at L = 10 m:

Calculate moment of inertia

$$I = \frac{bh^3}{12} = \frac{(0.150\ \text{m})(0.100\ \text{m})^3}{12} = 1.25\times10^{-5}\,\text{m}^4$$

C = 1 for pinned

$$F_{B_{10}} = \frac{\pi^2\ EI}{L^2} = \frac{\pi^2\left(70\times10^9\,\text{Pa}\right)\left(1.25\times10^{-5}\,\text{m}^4\right)}{(10\ \text{m})^2} = 86{,}271\ \text{N}$$

Check buckling at L = 5 m:

$$F_{B_5} = \frac{\pi^2\left(70\times10^9\,\text{Pa}\right)\left(1.25\times10^{-5}\,\text{m}^4\right)}{(5\ \text{m})^2} = 345{,}086\ \text{N}$$

Check maximum compressive load:

$\sigma = F/A$

$$F_{compressive} = A\sigma = (0.100\,\text{m})(0.150\,\text{m})\left(432\times10^6\ \text{N/m}^2\right)$$

$$= 6{,}480{,}000\ \text{N}$$

In either case, the column fails from buckling before compression.

By adding intermediate support, failure load increases from 86,271 N to 345,086 N, or by a factor of 4:

$$\frac{345{,}086\ \text{N}}{86{,}271\ \text{N}} = 4$$

THE CORRECT ANSWER IS: C

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Solution 71, p. 91

Intermediate column

$$1.5 \times 500 = \frac{\pi d^2}{4}\left[60 \times 10^3 - \frac{1^2}{30 \times 10^6} \bullet 3.6 \times 10^9 \times \left[\frac{4(7.07)^2}{d^2 \times 4\pi^2}\right]\right]$$

$$\frac{3,000}{\pi} = d^2\left[60 \times 10^3\right] - d^2\left[\frac{607.74}{d^2}\right]$$

$$\sqrt{\frac{1,562.67}{60 \times 10^3}} = d = 0.161$$

$$\text{Check } (S_r)_D = \sqrt{\frac{2\pi^2 E}{K^2 S_y}} = \sqrt{\frac{2\pi^2\left(30 \times 10^6\right)}{1^2\left(60 \times 10^3\right)}}$$

$$= 99.34$$

$$S_r = \frac{2(7.07)}{0.161} = 87$$

$S_r < (S_r)_D$; hence, intermediate column

$$\text{Compression strength} = \frac{500}{\frac{\pi}{4}\left(d^2\right)} = 30,000 \text{ psi}$$

$$\sqrt{\frac{2,000}{\pi(30,000)}} = d \qquad d = 0.145 \quad \text{required}$$

Compression governs diameter.

0.146

Check compressive stress required diameter.

Yield factor of safety = 2.0

$P = \sigma A$

$(500)(2) = (60,000\ \pi\ d^2)/4$

$1,000 = 47,124\ d^2$

$d = 0.146$ in.

THE CORRECT ANSWER IS: B

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Solution 73, p. 92

$I = \frac{\pi r^2}{4}$ $\quad J = \frac{\pi r^4}{2}$

$S_r = \frac{2\ell}{d}$ $\quad \text{Load} = 5.94 \times 3,000 = 17,820 \text{ lbf}$

Safety margin of 2

$\text{Load applied} = 2(17,820) = 35,650 \text{ lbf}$

Intermediate Column

$$35,640 = \frac{\pi}{4} d^2 \left[36,500 - \frac{1}{30 \times 10^6} \left(\frac{36,500^2 \times (100)^2}{4\pi^2 d^2} \right) \right]$$

$45,378.25 = d^2 [36,500] - 11,248.76$

$d = 1.245 = 1.25 \text{ in.}$

$S_r = \frac{2(50)}{1.25} = 80.285$

$(S_r)_D = \sqrt{\frac{2\pi^2 \times 30 \times 10^6}{1^2 \times 36,500}} = 127$

$S_r < (S_r)_D$; hence, intermediate

Compressive Yield:

$\sigma_y = 36,500 \frac{\text{lbf}}{\text{in}^2}$

$F = 35,620 \text{ lb}$

$\sigma = \frac{F}{A} \quad A = \frac{F}{\sigma_y} = 0.97 \quad r = \sqrt{\frac{A}{\pi}} = 0.55$

$d = 1.11 \text{ in.}$

$1.57 > 1.11$

THE CORRECT ANSWER IS: B

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Solution 76, p. 93

$$\phi = 80^\circ = 1.4\,\text{rad}$$

$$\mu' = \frac{\mu\left(4\sin\dfrac{\phi}{2}\right)}{\phi + \sin\phi} = 0.864$$