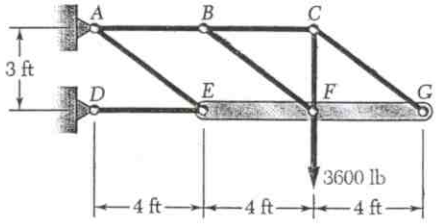
HW #1

Problem 1.11

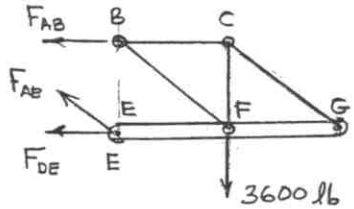
1.11 The rigid bar *EFG* is supported by the truss system shown. Knowing that the member *CG* is a solid circular rod of 0.75-in. diameter, determine the normal stress in *CG*.



Using portion EFGCB as a free body,

$+\uparrow \Sigma F_y = 0$: $\frac{3}{5} F_{AB} - 3600 = 0$

$F_{AE} = 6000$ lb.



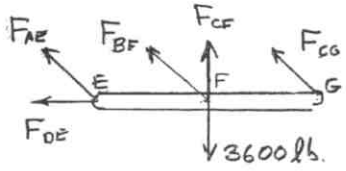
Using beam EFG as a free body,

$+\circlearrowleft M_F = 0$: $-(4)\frac{3}{5}F_{AE} + (4)\left(\frac{3}{5}F_{CG}\right) = 0$

$F_{CG} = F_{AE} = 6000$ lb.

Cross sectional area of member CG:

$A_{CG} = \frac{\pi}{4} d^2 = \frac{\pi}{4}(0.75)^2 = 0.44179 \text{ in}^2$



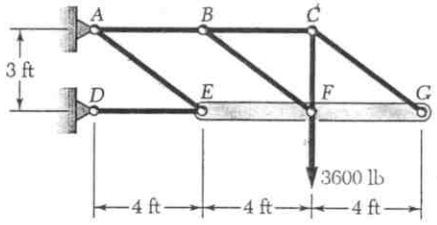
Normal stress in CG.

$\sigma_{CG} = \frac{F_{CG}}{A_{CG}} = \frac{6000}{0.44179} = 13580 \text{ psi}$

$\sigma_{CG} = 13.58 \text{ ksi}$ ◀

Problem 1.12

1.12 The rigid bar *EFG* is supported by the truss system shown. Determine the cross-sectional area of member *AE* for which the normal stress in the member is 15 ksi.

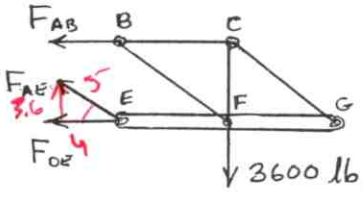


Using portion EFGCB as a free body,

$+\uparrow \Sigma F_y = 0$: $\frac{3}{5} F_{AE} - 3600 = 0$

$F_{AE} = 6000$ lb. $= 6.00$ kips

Stress in member AE: $\sigma_{AE} = 15$ ksi



$\sigma_{AE} = \frac{F_{AE}}{A_{AE}}$

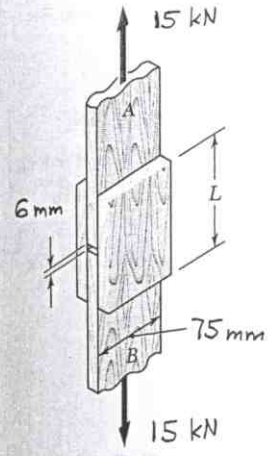
$A_{AE} = \frac{F_{AE}}{\sigma_{AE}} = \frac{6.00}{15}$

$A_{AE} = 0.400 \text{ in}^2$ ◀

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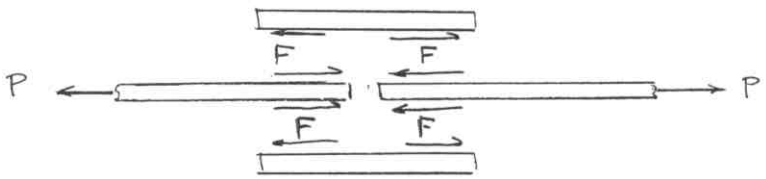
Problem 1.15

1.15 The wooden members A and B are to be joined by plywood splice plates that will be fully glued on the surfaces in contact. As part of the design of the joint, and knowing that the clearance between the ends of the members is to be 6 mm, determine the smallest allowable length L if the average shearing stress in the glue is not to exceed 700 kPa.



There are four separate areas that are glued. Each of these areas transmits one half the the 15 kN load. Thus

$$F = \tfrac{1}{2}P = \tfrac{1}{2}(15) = 7.5 \text{ kN} = 7500 \text{ N}$$



Let ℓ = length of one glued area and $W = 75 \text{ mm} = 0.075 \text{ m}$ be its width.

For each glued area, $A = \ell w$

Average shearing stress: $\tau = \dfrac{F}{A} = \dfrac{F}{\ell w}$

The allowable shearing stress is $\tau = 700 \times 10^3 \text{ Pa}$

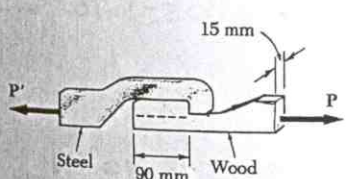
Solving for ℓ, $\ell = \dfrac{F}{\tau w} = \dfrac{7500}{(700 \times 10^3)(0.075)} = 0.14286 \text{ m} = 142.85 \text{ mm}$

Total length L: $L = \ell + (\text{gap}) + \ell = 142.85 + 6 + 142.85$

$$L = 292 \text{ mm}$$

Problem 1.16

1.16 When the force **P** reached 1600 lb, the wooden specimen shown failed in shear along the surface indicated by the dashed line. Determine the average shearing stress along that surface at the time of failure.



Area being sheared:
$A = (3 \text{ in.})(0.6 \text{ in.}) = 1.8 \text{ in}^2$

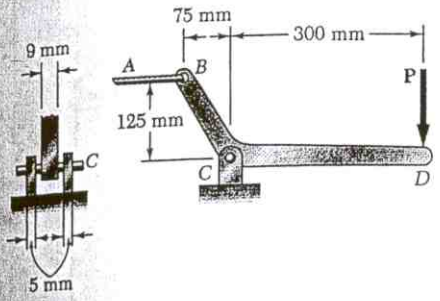
Force: $P = 1600 \text{ lb}$

Shearing stress: $\tau = \dfrac{P}{A} = \dfrac{1600}{1.8} = 889$ $\qquad \tau = 889 \text{ psi}$.

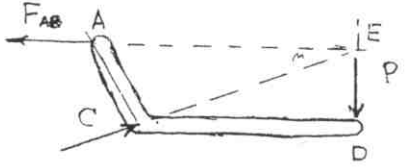
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Problem 1.23

1.23 A 6-mm-diameter pin is used at connection C of the pedal shown. Knowing that $P = 500$ N, determine (*a*) the average shearing stress in the pin, (*b*) the nominal bearing stress in the pedal at C, (*c*) the nominal bearing stress in each support bracket at C.



Draw free body diagram of ACD. Since ACD is a 3-force member, the reaction at C is directed toward point E, the intersection of the lines of action of the other two forces.



From geometry, $CE = \sqrt{300^2 + 125^2} = 325$ mm.

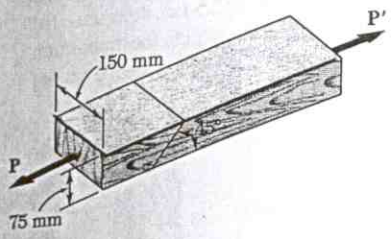
$+\uparrow \Sigma F_y = 0$: $\frac{125}{325} C - P = 0$ $\quad C = 2.6P = (2.6)(500) = 1300$ N

(a) $\tau_{pin} = \dfrac{\frac{1}{2}C}{A_{pin}} = \dfrac{\frac{1}{2}C}{\frac{\pi}{4}d^2} = \dfrac{2C}{\pi d^2} = \dfrac{(2)(1300)}{\pi(6\times10^{-3})^2} = 23.0\times10^6$ Pa $\quad \tau_{pin} = 23.0$ MPa

(b) $\sigma_b = \dfrac{C}{A_b} = \dfrac{C}{dt} = \dfrac{1300}{(6\times10^{-3})(9\times10^{-3})} = 24.1\times10^6$ Pa $\quad \sigma_b = 24.1$ MPa

(c) $\sigma_b = \dfrac{\frac{1}{2}C}{A_b} = \dfrac{C}{2dt} = \dfrac{1300}{(2)(6\times10^{-3})(5\times10^{-3})} = 21.7\times10^6$ Pa $\quad \sigma_b = 21.7$ MPa

Problem 1.31



1.31 Two wooden members of uniform rectangular cross section are joined by the simple glued scarf splice shown. Knowing that $P = 11$ kN, determine the normal and shearing stresses in the glued splice.

$\theta = 90° - 45° = 45°$

$P = 11\ \text{kN} = 11 \times 10^3\ \text{N}$

$A_o = (150)(75) = 11.25 \times 10^3\ \text{mm}^2 = 11.25 \times 10^{-3}\ \text{m}^2$

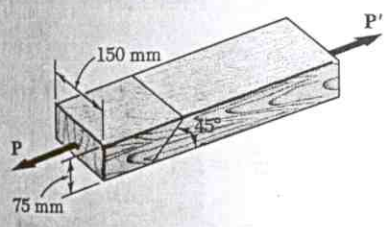
$$\sigma = \frac{P\cos^2\theta}{A_o} = \frac{(11 \times 10^3)\cos^2 45°}{11.25 \times 10^{-3}}$$

$$= 489 \times 10^3\ \text{Pa} \qquad \sigma = 489\ \text{kPA}$$

$$\tau = \frac{P\sin 2\theta}{2A_o} = \frac{(11 \times 10^3)(\sin 90°)}{(2)(11.25 \times 10^{-3})}$$

$$= 4.89 \times 10^3\ \text{Pa} \qquad \tau = 489\ \text{kPA}$$

Problem 1.32



1.32 Two wooden members of uniform rectangular cross section are joined by the simple glued scarf splice shown. Knowing that the maximum allowable tensile stress in the glued splice is 560 kPa, determine (*a*) the largest load **P** that can be safely applied, (*b*) the corresponding shearing stress in the splice.

$\theta = 90° - 45° = 45°$

$A_o = (150)(75) = 11.25 \times 10^3\ \text{mm}^2 = 11.25 \times 10^{-3}\ \text{m}^2$

$\sigma = 560\ \text{kPa} = 560 \times 10^3\ \text{Pa}$

$$\sigma = \frac{P\cos^2\theta}{A_o}$$

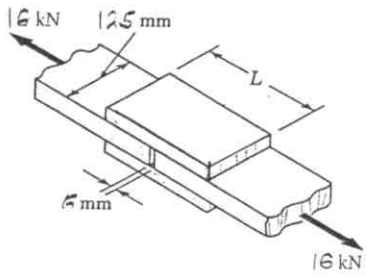
(a)
$$P = \frac{\sigma A_o}{\cos^2\theta} = \frac{(560 \times 10^3)(11.25 \times 10^{-3})}{\cos^2 45°}$$

$$= 12.60 \times 10^3\ \text{N} \qquad P = 12.60\ \text{kN}$$

(b)
$$\tau = \frac{P\sin\theta\cos\theta}{A_o} = \frac{(12.60 \times 10^3)(\sin 45°)(\cos 45°)}{11.25 \times 10^{-3}}$$

$$= 560 \times 10^3\ \text{Pa} \qquad \tau = 560\ \text{kPa}$$

Problem 1.43



1.43 The two wooden members shown, which support a 16-kN load, are joined by plywood splices fully glued on the surfaces in contact. The ultimate shearing stress in the glue is 2.5 MPa and the clearance between the members is 6 mm. Determine the required length L of each splice if a factor of safety of 2.75 is to be achieved.

There are 4 separate areas of glue. Each glue area must transmit 8 kN of shear load.

$$P = 8\ \text{kN} = 8\times10^{3}\ \text{N}$$

Required ultimate load.

$$P_U = (F.S.)P = (2.75)(8\times10^{3}) = 22\times10^{3}\ \text{N}$$

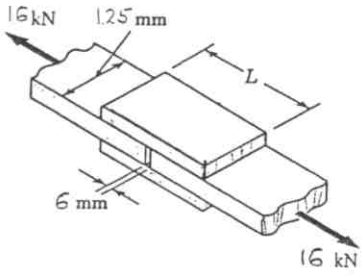
Required length of each glue area.

$$P_U = \tau_U A = \tau_U l w \qquad l = \frac{P_U}{\tau_U w} = \frac{22\times10^{3}}{(2.5\times10^{6})(0.125)} = 70.4\times10^{-3}\ \text{m}$$

Length of splice: $L = 2l + c = (2)(70.4\times10^{-3}) + 0.006 = 0.1468\times10^{-3}\ \text{m}$

$$L = 146.8\ \text{mm}$$

Problem 1.44



1.44 For the joint and loading of Prob. 1.43, determine the factor of safety, knowing that the length of each splice is $L = 180$ mm.

1.43 The two wooden members shown, which support a 16-kN load, are joined by plywood splices fully glued on the surfaces in contact. The ultimate shearing stress in the glue is 2.5 MPa and the clearance between the members is 6 mm. Determine the required length L of each splice if a factor of safety of 2.75 is to be achieved.

There are 4 separate areas of glue. Each glue area must transmit 8 kN of shear load.

$$P = 8\ \text{kN} = 8\times10^{3}\ \text{N}$$

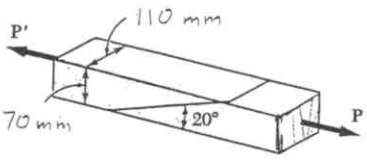
Length of splice. $L = 2l + c$ where l = length of glue and c = clearance. $l = \frac{1}{2}(L - c) = \frac{1}{2}(0.180 - 0.006) = 0.087\ \text{m}$

Area of glue. $A = lw = (0.087)(0.125) = 10.875\times10^{-3}\ \text{m}$

Ultimate load. $P_U = \tau_U A = (2.5\times10^{6})(10.875\times10^{-3}) = 27.1875\times10^{3}\ \text{N}$

Factor of safety. $F.S. = \frac{P_U}{P} = \frac{27.1875\times10^{3}}{8\times10^{3}}$ $\qquad F.S. = 3.40$

Problem 1.65



1.65 Two wooden members of 70 × 110-mm uniform rectangular cross section are joined by the simple glued scarf splice shown. Knowing that the maximum allowable shearing stress in the glued splice is 500 kPa, determine the largest axial load P that can be safely applied.

$$A_o = (0.070\,m)(0.110\,m) = 7.7\times10^{-3}\,m^2$$

$$\theta = 90^\circ - 20^\circ = 70^\circ$$

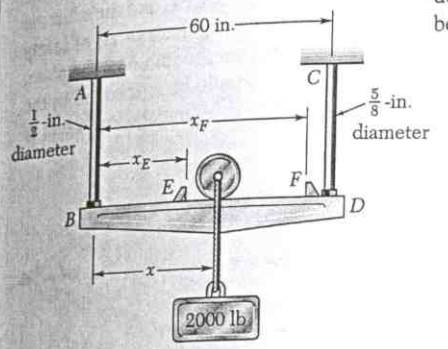
$$\tau = \frac{P}{A_o}\sin\theta\cos\theta$$

$$P = \frac{A_o\tau}{\sin\theta\cos\theta} = \frac{(7.7\times10^{-3})(500\times10^{3})}{\sin 70^\circ\cos 70^\circ} = 11.98\times10^{3}\,N$$

$$P = 11.98\,kN$$

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Problem 1.66

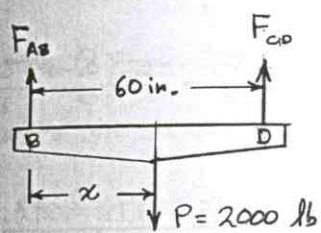


1.66 The 2000-lb load can be moved along the beam BD to any position between stops at E and F. Knowing that $\sigma_{all} = 6$ ksi for the steel used in rods AB and CD, determine where the stops should be placed if the permitted motion of the load is to be as large as possible.

Permitted member forces:

$$AB: \quad (F_{AB})_{max} = \sigma_{all} A_{AB} = (6)\left(\frac{\pi}{4}\right)\left(\frac{1}{2}\right)^2$$
$$= 1.17810 \text{ kips}$$

$$CD: \quad (F_{CD})_{max} = \sigma_{all} A_{CD} = (6)\left(\frac{\pi}{4}\right)\left(\frac{5}{8}\right)^2$$
$$= 1.84078 \text{ kips}$$



Use member BEFD as a free body.

$$P = 2000 \text{ lb} = 2.000 \text{ kips}$$

$$+\circlearrowleft \Sigma M_D = 0:$$
$$-(60) F_{AB} + (60 - x_E) P = 0$$
$$60 - x_E = \frac{60 F_{AB}}{P} = \frac{(60)(1.17810)}{2.000}$$
$$= 35.343$$
$$x_E = 24.7 \text{ in.}$$

$$+\circlearrowleft \Sigma M_B = 0:$$
$$60 F_{CD} - x P = 0$$
$$x_F = \frac{60 F_{CD}}{P} = \frac{(60)(1.84078)}{2.000}$$
$$x_F = 55.2 \text{ in.}$$

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