**CHAPTER 1**

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| bee98233_p0101-02 | Problem 1.1  Two solid cylindrical rods *AB* and *BC* are welded together at *B* and loaded as shown. Knowing that  and  find the average normal stress at the midsection of (*a*) rod *AB*, (*b*) rod *BC*. |

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| Solution  (*a*) Rod *AB*:  Force:  Area:  Normal stress:     (*b*) Rod *BC*:  Force:  Area:  Normal stress:   |

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| bee98233_p0101-02 | Problem 1.2  Two solid cylindrical rods *AB* and *BC* are welded together at *B* and loaded as shown. Knowing that the average normal stress must not exceed 150 MPa in either rod, determine the smallest allowable values of the diameters *d*1 and *d*2. |

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| Solution  (*a*) Rod *AB*:  Force:  Stress:  Area:      (*b*) Rod *BC*:  Force:  Stress:  Area:     |

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| bee98233_p0103-04 | Problem 1.3  Two solid cylindrical rods *AB* and *BC* are welded together at *B* and loaded as shown. Knowing that *P* = 10 kips, find the average normal stress at the midsection of (*a*) rod *AB*, (*b*) rod *BC*. |

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| Solution  (*a*) Rod *AB*:    (*b*) Rod *BC*:   |

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| bee98233_p0103-04 | Problem 1.4  Two solid cylindrical rods *AB* and *BC* are welded together at *B* and loaded as shown. Determine the magnitude of the force **P** for which the tensile stresses in rods *AB* and *BC* are equal. |

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| Solution  (*a*) Rod *AB*:    (*b*) Rod *BC*:     |

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| bee98233_p0105 | Problem 1.5  A strain gage located at *C* on the surface of bone *AB* indicates that the average normal stress in the bone is 3.80 MPa when the bone is subjected to two 1200-N forces as shown. Assuming the cross section of the bone at *C* to be annular and knowing that its outer diameter is 25 mm, determine the inner diameter of the bone’s cross section at *C*. |

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| Solution    Geometry:   |

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| bee98233_p0162 | Problem 1.6  Two steel plates are to be held together by means of 16-mm-diameter high-strength steel bolts fitting snugly inside cylindrical brass spacers. Knowing that the average normal stress must not exceed 200 MPa in the bolts and 130 MPa in the spacers, determine the outer diameter of the spacers that yields the most economical and safe design. |

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| Solution  At each bolt location the upper plate is pulled down by the tensile force *Pb* of the bolt. At the same time, the spacer pushes that plate upward with a compressive force *Ps* in order to maintain equilibrium.    For the bolt,  or  For the spacer,  or  Equating  and   |

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| bee98233_p0107 | Problem 1.7  Each of the four vertical links has an  uniform rectangular cross section and each of the four pins has a 16-mm diameter. Determine the maximum value of the average normal stress in the links connecting (*a*) points *B* and *D*, (*b*) points *C* and *E*. |

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| \\nodnas1\art5\RPK\BeerMoM-7e\Final\Ch01\bee02286_s01007.tifSolution  Use bar *ABC* as a free body.      Net area of one link for tension  For two parallel links,  (*a*)     Area for one link in compression  For two parallel links,  (*b*)    |

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| bee98233_p0108 | Problem 1.8  Link AC has a uniform rectangular cross section  in. thick and 1 in. wide. Determine the normal stress in the central portion of the link. |

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| Solution  Use the plate together with two pulleys as a free body. Note that the cable tension causes at 1200 lb-in. clockwise couple to act on the body.  **bee02286_s01008**  **PlusRightCounterHighArrow**  Area of link *AC*:  Stress in link *AC*:   |

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|  | Problem 1.9  Knowing that the central portion of the link *BD* has a uniform cross-sectional area of 800 mm2, determine the magnitude of the load **P** for which the normal stress in that portion of *BD* is 50 MPa.. |

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| Solution  Draw free body diagram of link *AC*.        Free Body *AC*: **PlusRightCounterHighArrow**   |

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| bee98233_p0110 | Problem 1.10  Link BD consists of a single bar 1 in. wide and  in. thick. Knowing that each pin has a -in. diameter, determine the maximum value of the average normal stress in link BD if (*a*)  = 0, (*b*)  = 90°. |

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| Solution  Use bar *ABC* as a free body.  \\nodnas1\art5\RPK\BeerMoM-7e\Final\Ch01\bee02286_s01010.tif  (*a*)  **PlusRightCounterHighArrow**  Area for tension loading:  Stress:     (*b*)  **PlusRightCounterHighArrow**  Area for compression loading:  Stress:    |

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|  | Problem 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*. |

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| Solution | Using portion *EFGCB* as free body,  arr2  Use beam *EFG* as free body.  **PlusRightCounterHighArrow**    Normal stress in member *CG*  Area:     |

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|  | Problem 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. |

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| Solution | Using portion *EFGCB* as free body,  arr2  Normal stress in member *AE* = 15 ksi     |

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| bee98233_p0113 | Problem 1.13  An aircraft tow bar is positioned by means of a single hydraulic cylinder connected by a 25-mm-diameter steel rod to two identical arm-and-wheel units *DEF*. The mass of the entire tow bar is 200 kg, and its center of gravity is located at *G*. For the position shown, determine the normal stress in the rod. |

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| Solution  bee29389_s01014a  bee29389_s01014b | FREE BODY – ENTIRE TOW BAR:  **PlusRightCounterHighArrow**  FREE BODY – BOTH ARM & WHEEL UNITS:    **PlusRightCounterHighArrow**   |

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| bee98233_p0114 | Problem 1.14  Two hydraulic cylinders are used to control the position of the robotic arm *ABC*. Knowing that the control rods attached at *A* and *D* each have a 20-mm diameter and happen to be parallel in the position shown, determine the average normal stress in (*a*) member *AE*, (*b*) member *DG*. |

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| Solution  Use member *ABC* as free body.  bee02286_s01014a  **PlusRightCounterHighArrow**  Area of rod in member *AE* is  Stress in rod *AE*:  (*a*)   Use combined members *ABC* and *BFD* as free body.  bee02286_s01014b  **PlusRightCounterHighArrow**  Area of rod *DG*:  Stress in rod *DG*:  (*b*) |

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| Problem 1.15  Knowing that a force **P** of magnitude 50 kN is required to punch a hole of diameter *d* = 20 mm in an aluminum sheet of thickness *t* = 5 mm, determine the average shearing stress in the aluminum at failure. |

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| Solution  Area of failure in plate:    Average shearing stress:     |

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| bee98233_p0116 | Problem 1.16  Two wooden planks, each  thick and  wide, are joined by the dry mortise joint shown. Knowing that the wood used shears off along its grain when the average shearing stress reaches 1.20 ksi, determine the magnitude *P* of the axial load that will cause the joint to fail. |

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| Solution  Six areas must be sheared off when the joint fails. Each of these areas has dimensions  its area being    At failure, the force carried by each area is    Since there are six failure areas,   |

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| bee98233_p0117 | Problem 1.17  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. |

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| Solution  Area being sheared:  Force:  Shearing stress:    |

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| bee98233_p0118 | Problem 1.18  A load **P** is applied to a steel rod supported as shown by an aluminum plate into which a 12-mm-diameter hole has been drilled. Knowing that the shearing stress must not exceed 180 MPa in the steel rod and 70 MPa in the aluminum plate, determine the largest load **P** that can be applied to the rod. |

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| Solution  For steel:    For aluminum:    Limiting value of *P* is the smaller value, so   |

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| bee98233_p0119 | Problem 1.19  The axial force in the column supporting the timber beam shown is *P* kips. Determine the smallest allowable length *L* of the bearing plate if the bearing stress in the timber is not to exceed 400 psi. |

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| Solution  Bearing area:   |

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| bee98233_p0120 | Problem 1.20  Three wooden planks are fastened together by a series of bolts to form a column. The diameter of each bolt is 12 mm and the inner diameter of each washer is 16 mm, which is slightly larger than the diameter of the holes in the planks. Determine the smallest allowable outer diameter *d* of the washers, knowing that the average normal stress in the bolts is 36 MPa and that the bearing stress between the washers and the planks must not exceed 8.5 MPa. |

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| Solution  Bolt:  Tensile force in bolt:    Bearing area for washer:  and  Therefore, equating the two expressions for *Aw* gives     |

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| bee98233_p0121 | Problem 1.21  A 40-kN axial load is applied to a short wooden post that is supported by a concrete footing resting on undisturbed soil. Determine (*a*) the maximum bearing stress on the concrete footing, (*b*) the size of the footing for which the average bearing stress in the soil is 145 kPa. |

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| Solution  (*a*) Bearing stress on concrete footing.    (*b*) Footing area.    Since the area is square,   |

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|  | Problem 1.22  The axial load *P* = 240 kips, supported by a W10 × 45 column, is distributed to a concrete foundation by a square base plate as shown. Determine the size of the base plate for which the average bearing stress on the concrete is 750 psi. |

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| Solution  or    Since the plate is square,     |

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| bee98233_p0122 | Problem 1.23  An axial load **P** is supported by a short  column of cross-sectional area  and is distributed to a concrete foundation by a square plate as shown. Knowing that the average normal stress in the column must not exceed 30 ksi and that the bearing stress on the concrete foundation must not exceed 3.0 ksi, determine the side *a* of the plate that will provide the most economical and safe design. |

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| Solution  For the column,  or    For the  plate,    Since the plate is square,   |

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|  | Problem 1.24  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*. |

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| Solution  Since *BCD* is a 3-force member, the reaction at *C* is directed toward *E,* the intersection of the lines of act of the other two forces.    From geometry,  From the free body diagram of *BCD,*  arr2  (*a*)      (*b*)    (*c*)   |

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|  | Problem 1.25  Knowing that a force **P** of magnitude 750 N is applied to the pedal shown, determine (*a*) the diameter of the pin at *C* for which the average shearing stress in the pin is 40 MPa, (*b*) the corresponding bearing stress in the pedal at *C*, (*c*) the corresponding bearing stress in each support bracket at *C*. |

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| Solution  Since *BCD* is a 3-force member, the reaction at *C* is directed toward *E,* the intersection of the lines of action of the other two forces.    From geometry,  From the free body diagram of *BCD,*  arr2  (*a*)      (*b*)    (*c*)   |

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| bee98233_p0126 | Problem 1.26  The hydraulic cylinder *CF*, which partially controls the position of rod *DE*, has been locked in the position shown. Member *BD* is 15 mm thick and is connected at C to the vertical rod by a 9-mm-diameter bolt. Knowing that *P*  2 kN and  determine (*a*) the average shearing stress in the bolt, (*b*) the bearing stress at *C* in member *BD*. |

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| Solution  Free Body: Member *BD*.  \\nodnas1\art5\RPK\BeerMoM-7e\Final\Ch01\bee02286_s01026.tif  **PlusRightCounterHighArrow**      arrow  arr2  angle 11 86.2°  (*a*)    (*b*)   |

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| bee98233_p0107 | Problem 1.27  For the assembly and loading of Prob. 1.7, determine (*a*) the average shearing stress in the pin at *B*, (*b*) the average bearing stress at *B* in member *BD*, (*c*) the average bearing stress at *B* in member *ABC*, knowing that this member has a 10 × 50-mm uniform rectangular cross section.  **PROBLEM 1.7** Each of the four vertical links has an 8 × 36-mm uniform rectangular cross section and each of the four pins has a 16-mm diameter. Determine the maximum value of the average normal stress in the links connecting (*a*) points *B* and *D*, (*b*) points *C* and *E*. |

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| Solution  Use bar *ABC* as a free body.  bee29389_s01027**PlusRightCounterHighArrow**  (*a*) Shear pin at *B*.  for double shear  where    (*b*) Bearing: link *BD*.    (*c*) Bearing in *ABC* at *B*.   |

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| bee98233_p0128 | Problem 1.28  Two identical linkage-and-hydraulic-cylinder systems control the position of the forks of a fork-lift truck. The load supported by the one system shown is 1500 lb. Knowing that the thickness of member *BD* is  in., determine (*a*) the average shearing stress in the -in.-diameter pin at *B*, (*b*) the bearing stress at *B* in member *BD*. |

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| Solution  \\nodnas1\art5\RPK\BeerMoM-7e\Final\Ch01\bee02286_s01028.tifUse one fork as a free body.  **PlusRightCounterHighArrow**  **ArrowRight**  arrow  **ArrowLeft**  arr2  (*a*) Shearing stress in pin at *B*.      (*b*) Bearing stress at *B*.   |