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| bee98233_p01c1 | Problem 1.C1  A solid steel rod consisting of *n* cylindrical elements welded together is subjected to the loading shown. The diameter of element *i* is denoted by *di* and the load applied to its lower end by **P***i* with the magnitude *Pi* of this load being assumed positive if **P***i* is directed downward as shown and negative otherwise. (*a*) Write a computer program that can be used with either SI or U.S. customary units to determine the average stress in each element of the rod. (*b*) Use this program to solve Problems 1.1 and 1.3. |

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| Solution  Force in element *i*:  It is the sum of the forces applied to that element and all lower ones:    Average stress in element *i*:    Program outputs:     |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Problem 1.1** | |  | **Problem 1.3** | | | **Element** | **Stress (MPa)** |  | **Element** | **Stress (ksi)** | | 1 | 84.883 |  | 1 | 22.635 | | 2 | 96.766 |  | 2 | 17.927 | |  |  |  |  |  | |

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| bee98233_p01c2 | Problem 1.c2  A 20-kN load is applied as shown to the horizontal member *ABC*. Member *ABC* has a  uniform rectangular cross section  and is supported by four vertical links, each of  uniform rectangular cross section. Each of the four pins at *A*, *B*, *C*, and *D* has the same diameter *d* and is in double shear. (*a*) Write a computer program to calculate for values of *d* from 10 to 30 mm, using 1-mm increments, (i) the maximum value of the average normal stress in the links connecting pins *B* and *D*, (ii) the average normal stress in the links connecting pins *C* and *E*, (iii) the average shearing stress in pin *B*,  (iv) the average shearing stress in pin *C*, (v) the average bearing stress at *B* in member *ABC*, and (vi) the average bearing stress at *C* in member *ABC*. (*b*) Check your program by comparing the values obtained for  *d*  16 mm with the answers given for Probs. 1.7 and 1.27. (*c*) Use this program to find the permissible values of the diameter *d* of the pins, knowing that the allowable values of the normal, shearing, and bearing stresses for the steel used are, respectively, 150 MPa, 90 MPa, and  230 MPa. (*d*) Solve Part *c*, assuming that the thickness of member *ABC* has been reduced from 10 to 8 mm. |

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| Solution  P = 20 kN  Forces in links.  *F.B*. diagram of *ABC*:  Left-ArrowPlus  bee29389_s01c2a Left-ArrowPlus   |  |  | | --- | --- | | bee29389_s01c2b(i) Link *BD*.  Thickness     (iii) Pin *B*.    (v) Bearing stress at *B*.  Thickness of member    (vi) Bearing stress at *C*.  Sig Bear | (ii) Link *CE*.  Thickness     bee29389_s01c2c(iv) Pin *C*.  bee29389_s01c2d  Shearing stress in *ABC* under Pin *B*. | |

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| |  | | --- | | PROBLEM 1.c2 *(Continued)*  **Program Outputs**  Input data for Parts (*a*), (*b*), (*c*):  *P*  20 kN, *AB*  0.25 m, *BC*  0.40 m, *AC*  0.65 m,  *TL*  8 mm, *WL*  36 mm, *TAC*  10 mm, *WAC*  50 mm |   bee29389_p01c2a   |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  | (c) Answer: 16 mm  (c) | | | | | | | Check: For *d*  22 mm, Tau *AC* = 65 MPa < 90 MPa O.K. | | | |  |  |  |  |  | |

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| PROBLEM 1.c2 *(Continued)*  Input data for Part (*d*): *P*  20 kN,  *AB* = 0.25 m, *BC* = 0.40 m,  *AC* = 0.65 m, *TL* = 8 mm, *WL* = 36 mm,  *TAC*  8 mm, *WAC*  50 mm  bee29389_p01c2b   |  |  |  |  | | --- | --- | --- | --- | |  |  |  | (d) Answer: 18 mm (d) |   Check: For *d* = 22 mm, Tau *AC* = 81.25 MPa < 90 MPa O.K. |

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| bee98233_p01c3 | Problem 1.c3  Two horizontal 5-kip forces are applied to Pin *B* of the assembly shown. Each of the three pins at *A*, *B*, and *C* has the same diameter *d* and is double shear. (*a*) Write a computer program to calculate for values of *d* from 0.50 to 1.50 in., using 0.05-in. increments, (i) the maximum value of the average normal stress in member *AB*, (ii) the average normal stress in member *BC*, (iii) the average shearing stress in pin *A*, (iv) the average shearing stress in pin *C*, (v) the average bearing stress at *A* in member *AB*, (vi) the average bearing stress at *C* in member *BC*, and (vii) the average bearing stress at *B* in member *BC*.  (*b*) Check your program by comparing the values obtained for  *d*  0.8 in. with the answers given for Problems 1.60 and 1.61. (*c*) Use this program to find the permissible values of the diameter *d* of the pins, knowing that the allowable values of the normal, shearing, and bearing stresses for the steel used are, respectively, 22 ksi, 13 ksi, and 36 ksi. (*d*) Solve Part *c*, assuming that a new design is being investigated in which the thickness and width of the two members are changed, respectively, from 0.5 to 0.3 in. and from 1.8 to 2.4 in. |

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| Solution  Forces in members *AB* and *BC*.  Free body: Pin *B*.  From force triangle:  bee29389_s01c3a   |  |  | | --- | --- | | (i) Max. ave. stress in *AB*.  Width  *w*  Thickness  *t*    bee29389_s01c3b(iii) Pin *A*.    (v) Bearing stress at *A*.  Sig Bear  (vii) Bearing stress at *B* in member *BC*.  Sig Bear | (ii) Ave. stress in *BC*.    (iv) Pin *C*.    bee29389_s01c3c(vi) Bearing stress at *C*.  Sig Bear | |  | |   PROBLEM 1.C3 *(Continued)*  **Program Outputs**  Input data for Parts (*a*), (*b*), (*c*):  *P* = 5 kips, *w* = 1.8 in., *t* = 0.5 in.  bee29389_p01c3a   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  |  | (c) Answer: 0.70 in. | (c) | |

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| PROBLEM 1.C3 *(Continued)*  Input data for Part (*d*),  *P* = 5 kips, *w*  2.4 in., *t*  0.3 in.  bee29389_p01c3b   |  |  |  |  | | --- | --- | --- | --- | |  |  |  | (d) Answer: 0.85 in.  (d) | |

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| bee98233_p01c4 | Problem 1.c4  A 4-kip force **P** forming an angle ** with the vertical is applied as shown to member *ABC*, which is supported by a pin and bracket at *C* and by a cable *BD* forming an angle ** with the horizontal. (*a*) Knowing that the ultimate load of the cable is 25 kips, write a computer program to construct a table of the values of the factor of safety of the cable for values of and  from 0 to 45°, using increments in ** and ** corresponding to 0.1 increments in tan and tan . (*b*) Check that for any given value of **, the maximum value of the factor of safety is obtained for  and explain why. (*c*) Determine the smallest possible value of the factor of safety for  as well as the corresponding value of **, and explain the result obtained. |

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| bee29389_s01c4aSolution  (a) Draw *F.B.* diagram of *ABC*:  **PlusRightCounterHighArrow**    bee29389_p01c4b  (b) When  and cable *BD* is perpendicular to the lever arm *BC*.  (c)  for  *P* is perpendicular to the lever arm *AC*.  *Note:* The value  is the smallest of the values of *F.S.* corresponding to  and the largest of those corresponding to  The point  is a “saddle point,” or “minimax” of the function |

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| bee98233_p01c5 | Problem 1.C5  A load **P** is supported as shown by two wooden members of uniform rectangular cross section that are joined by a simple glued scarf splice. (*a*) Denoting by  and  respectively, the ultimate strength of the joint in tension and in shear, write a computer program which, for given values of *a*, *b*, *P*,  and  expressed in either SI or U.S. customary units, and for values of  from 5 to 85° at 5° intervals, can be used to calculate (i) the normal stress in the joint, (ii) the shearing stress in the joint, (iii) the factor of safety relative to failure in tension, (iv) the factor of safety relative to failure in shear, and (v) the overall factor of safety for the glued joint. (*b*) Apply this program, using the dimensions and loading of the members of Probs. 1.29 and 1.31, knowing that  and  for the glue used in Prob. 1.29, and that  and  for the glue used in Prob. 1.31. (*c*) Verify in each of these two cases that the shearing stress is maximum for |

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| Solution  (i) and (ii) Draw the *F.B.* diagram of lower member:  arrow 0001  arrow 0002  Area  Normal stress:  Shearing stress:  bee29389_s01c5a(iii) *F.S.* for tension (normal stresses):    (iv) *F.S.* for shear:    (v) Overall *F.S.*:  *F.S.*  The smaller of *FSN* and *FSS*.  PROBLEM 1.C5 *(Continued)*  **Program Outputs**  Problem 1.29     |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | ALPHA | SIG (MPa) | TAU (MPa) | FSN | FSS | FS |  | | 5 | 0.007 | 0.085 | 169.644 | 17.669 | 17.669 |  | | 10 | 0.029 | 0.167 | 42.736 | 8.971 | 8.971 |  | | 15 | 0.065 | 0.244 | 19.237 | 6.136 | 6.136 |  | | 20 | 0.114 | 0.314 | 11.016 | 4.773 | 4.773 |  | | 25 | 0.175 | 0.375 | 7.215 | 4.005 | 4.005 |  | | 30 | 0.244 | 0.423 | 5.155 | 3.543 | 3.543 |  | | 35 | 0.322 | 0.459 | 3.917 | 3.265 | 3.265 |  | | 40 | 0.404 | 0.481 | 3.119 | 3.116 | 3.116 |  | | 45 | 0.489 | 0.489 | 2.577 | 3.068 | 2.577 |  (b), (c) | | 50 | 0.574 | 0.481 | 2.196 | 3.116 | 2.196 |  | | 55 | 0.656 | 0.459 | 1.920 | 3.265 | 1.920 |  | | 60 | 0.733 | 0.423 | 1.718 | 3.543 | 1.718 |  | | 65 | 0.803 | 0.375 | 1.569 | 4.005 | 1.569 |  | | 70 | 0.863 | 0.314 | 1.459 | 4.773 | 1.459 |  | | 75 | 0.912 | 0.244 | 1.381 | 6.136 | 1.381 |  | | 80 | 0.948 | 0.167 | 1.329 | 8.971 | 1.329 |  | | 85 | 0.970 | 0.085 | 1.298 | 17.669 | 1.298 |  |   PROBLEM 1.C5 *(Continued)*  Problem 1.31     |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | ALPHA | SIG (psi) | TAU (psi) | FSN | FSS | FS |  | | 5 | 0.709 | 8.104 | 211.574 | 26.408 | 26.408 |  | | 10 | 2.814 | 15.961 | 53.298 | 13.408 | 13.408 |  | | 15 | 6.252 | 23.333 | 23.992 | 9.171 | 9.171 |  | | 20 | 10.918 | 29.997 | 13.739 | 7.134 | 7.134 |  | | 25 | 16.670 | 35.749 | 8.998 | 5.986 | 5.986 |  | | 30 | 23.333 | 40.415 | 6.429 | 5.295 | 5.295 |  | | 35 | 30.706 | 43.852 | 4.885 | 4.880 | 4.880 |  | | 40 | 38.563 | 45.958 | 3.890 | 4.656 | 3.890 |  | | 45 | 46.667 | 46.667 | 3.214 | 4.586 | 3.214 |  (c) | | 50 | 54.770 | 45.958 | 2.739 | 4.656 | 2.739 |  | | 55 | 62.628 | 43.852 | 2.395 | 4.880 | 2.395 |  | | 60 | 70.000 | 40.415 | 2.143 | 5.295 | 2.143 |  (b) | | 65 | 76.663 | 35.749 | 1.957 | 5.986 | 1.957 |  | | 70 | 82.415 | 29.997 | 1.820 | 7.134 | 1.820 |  | | 75 | 87.081 | 23.333 | 1.723 | 9.171 | 1.723 |  | | 80 | 90.519 | 15.961 | 1.657 | 13.408 | 1.657 |  | | 85 | 92.624 | 8.104 | 1.619 | 26.408 | 1.619 |  | |

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| bee98233_p01c6 | Problem 1.C6  Member *ABC* is supported by a pin and bracket at *A* and by two links, which are pin-connected to the member at *B* and to a fixed support at *D*. (*a*) Write a computer program to calculate the allowable load  for any given values of (i) the diameter  of the pin at *A*, (ii) the common diameter *d*2 of the pins at *B* and *D*, (iii) the ultimate normal stress *σU* in each of the two links, (iv) the ultimate shearing stress  in each of the three pins, and (v) the desired overall factor of safety *F.S.* (*b*) Your program should also indicate which of the following three stresses is critical: the normal stress in the links, the shearing stress in the pin at *A,* or the shearing stress in the pins at *B* and *D*. (*c*) Check your program by using the data of Probs. 1.55 and 1.56, respectively, and comparing the answers obtained for *P*all with those given in the text. (*d*) Use your program to determine the allowable load *P*all, as well as which of the stresses is critical, when    for aluminum links,  for steel pins, and *F.S.*  3.2. |

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| Solution  (a) *F.B.* diagram of *ABC*:    bee29389_s01c6a(i)  (ii)  (iii) For ultimate stress in links *BD*:  (iv) For ultimate shearing stress in pins:  is the smaller of  and  (v) For desired overall *F.S.*:  is the smaller of  and  If  stress is critical in links.  If  and  stress is critical in Pin *A*.  If  and  stress is critical in Pins *B* and *D*.  PROBLEM 1.C6 *(Continued)*  **Program Outputs**  (b) Problem 1.55. Data:  Stress in Pin *A* is critical.   (c) Problem 1.56. Data:  Stress in Pins *B* and *D* is critical.   (d) Data:  Stress in links is critical.  |