60. In Fig. 34, a boat is being pushed forward against a resistance of $Q = 50$ lb. If the resultant force in the x direction is $R = +100$ lb., determine F and θ algebraically and graphically. *Ans.* 90 lb., 26.4°.

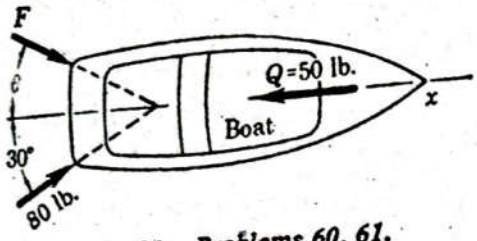


Fig. 34. Problems 60, 61.

61. The same as 60 except that $R = +200$ lb.

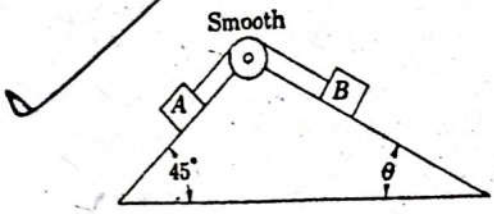


Fig. 35. Problems 62, 63.

62. In Fig. 35, the bodies A and B, connected by a cord and resting on smooth planes, weigh $W_A = 50$ lb. and $W_B = 30$ lb. The body A is acted on by a force in such a manner that the tension in the cord is 30 lb. If the normal reaction between B and the plane is 25.98 lb., what is the resulting force on B?

Ans. 15 lb. up the plane.

63. The same as 62 except that the tension in the cord is 20 lb.

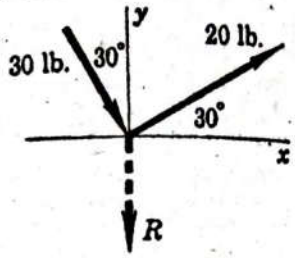


Fig. 36. Problems 64, 65.

64. The resultant $R = 60$ lb. shown in Fig. 36, is the resultant of the 20-lb. and 30-lb. forces and another force F. What is the force F? *Ans.* 54.7 lb., $\theta = 233.7°$.

65. The same as 64 except that $R = 25$ lb.

EQUILIBRIUM

66. A weight $W = 1000$ lb. is suspended from a pin B which unites two inclined timbers AB and CB, Fig. 37. Determine algebraically and graphically the compressive force on each timber. *Ans.* 578 lb.

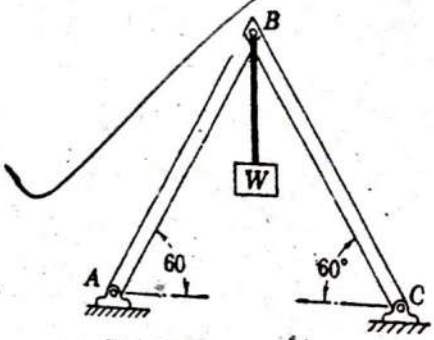


Fig. 37. Problems 66, 67.

67. In Fig. 37, if the horizontal and vertical components of the reaction at C are $C_x = 500$ lb. and $C_y = 866$ lb., find W.
HINT: Observe that BC is a two-force member.

68. The permissible internal force on timber AB, Fig. 38, is 4 kips. If $\theta = 30°$, what maximum safe load may be suspended at B? Solve algebraically and graphically. *Ans.* 4460 lb.

69. The permissible internal force on timber AB, Fig. 38, is 25,000 lb. If $\theta = 20°$, what maximum safe load W may be suspended at B? Solve algebraically and graphically.

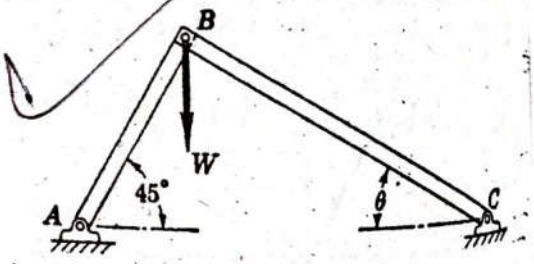


Fig. 38. Problems 68-70.

70. In Fig. 38, if $W = 100$ lb. and the reaction at A is 75 lb., find the reaction at C and the angle θ. Solve algebraically and graphically. *Ans.* 70.9 lb., 41.6°.

71. A span of telephone wire is suspended from crossarms of equal elevation and the horizontal span is 200 ft. When a 10-lb. buzzard alights in the center of the span, the sag is observed to be 2 ft. Consider the wire on each side of the bird as a straight line and neglect the weight of the wire. (a) Find the force in the wire caused by the

bird. (b) Reduce the sag to 6 in. and recalculate your answer. Solve algebraically and graphically.

72. A 5000-lb. sphere rests on a smooth plane inclined at an angle $\theta = 45°$ with the horizontal and against a smooth vertical wall. What are the reactions at the contact surfaces A and B, Fig. 39?

Ans. 5000 lb., 7070 lb.

73. The same as **72** except that $\theta = 75°$.

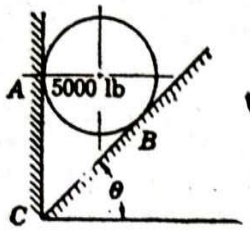


Fig. 39. Problems 72-75.

74. In Fig. 39, the greatest force at A or B caused by the 5000-lb. sphere must not exceed 10,000 lb. if permanent deformation of the surfaces is to be avoided. Find the largest value θ may safely have. *Ans.* 60°.

75. The same as **74** except that the sphere weighs only 800 lb.

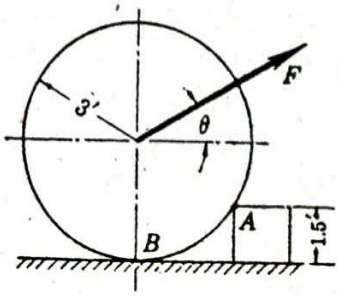


Fig. 40. Problems 76-78.

76. A 2500-lb. wheel with a radius of 3 ft. is acted upon by a force F, Fig. 40, which tends to pull the wheel over the obstruction at A. At the instant the wheel is about to move, the pressure between the wheel and the ground is zero. What is the magnitude of the force F at this instant if $\theta = 30°$?

Ans. 2500 lb.

77. The same as **76** except that $\theta = 40°$.

78. The same as **76** except that the weight of the wheel is 4000 lb.

79. A 500-lb. cylinder A rests on a smooth inclined plane, Fig. 41. For a tension in the rope of 250 lb. find the inclination of the plane and the plane reaction. Solve algebraically and graphically.

Ans. 30°, 433 lb.

80. The same as **79** except that the tension in the rope is 400 lb.

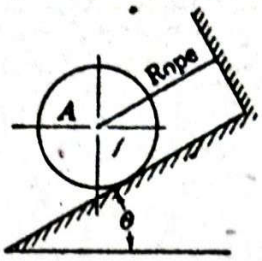


Fig. 41. Problems 79, 80.

81. A captive balloon in a balloon barrage exerts a net vertical lifting force of 10,000 lb. Its own weight is 1000 lb. A horizontal wind causes the cable to which it is attached to slope at an angle of 30° with the vertical. What is the force of the wind on the balloon? *Ans.* 5200 lb.

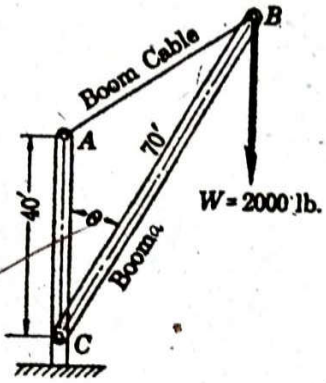


Fig. 42. Problems 82, 83.

82. The derrick shown diagrammatically in Fig. 42 supports a load of $W = 2$ kips. Find the tension in the boom cable and the compression in the boom when the angle θ is (a) 30°, (b) 90°, and (c) 150°. Which position produces the largest load on the boom? *Ans.* All in kips: (a) 3.5, 2.03; (b) 3.5, 4.03; (c) 3.5, 5.33.

83. The same as **82** except add the following: (d) Prove that the compressive load on the boom is constant. (e) Does your proof include the conditions of $\theta = 0°$ or $\theta = 180°$?

84. What are the forces on the members AB and BC, Fig. 43, if $\theta = 30°$? Solve graphically and algebraically.

Ans. 7120 lb.(C), 440 lb.(T).

85. The same as **84** except that $\theta = 60°$.

86. Two spheres are at rest against smooth surfaces, as shown in Fig. 44. Sphere A weighs 3200 lb. and sphere B weighs 400 lb. Let $F = 1000$ lb. and $\theta =$

90°, and find the reactions at C, D, and E. Solve algebraically and graphically. *Ans.* 850 lb., 3600 lb., 1850 lb.

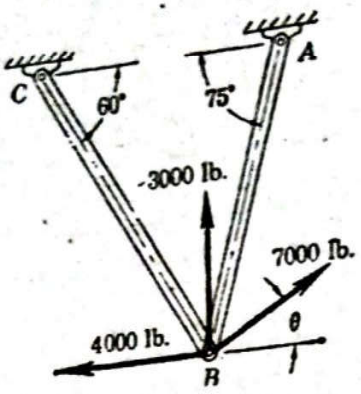


Fig. 43. Problems 84, 85.

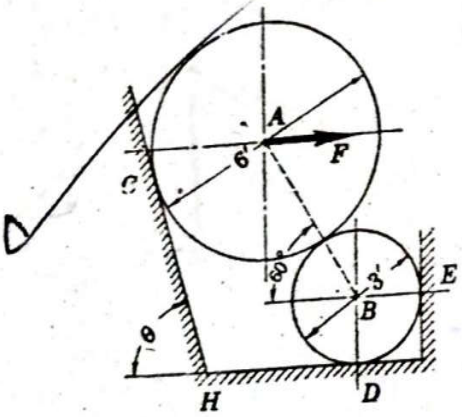


Fig. 44. Problems 86-88.

87. The same as **86** except that $F = 0$.

88. The same as **86** except that $\theta = 75°$. *Ans.* 760 lb., 3403 lb., 1734 lb.

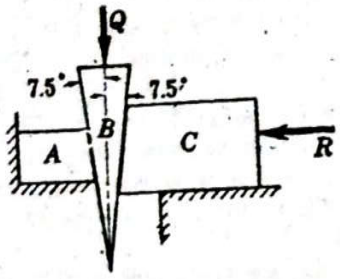


Fig. 45. Problems 89, 90.

89. In Fig. 45, let $W_A = 2000$ lb., $W_B = 500$ lb., $W_C = 5000$ lb., and force $R = 8000$ lb. Neglecting all friction so that the reactions are normal to the surfaces, find the force Q on top of the wedge. Solve algebraically and graphically. Assume that each body is subjected to a concurrent force system. *Ans.* 1600 lb.

90. The same as **89** except that $R = 1800$ lb.

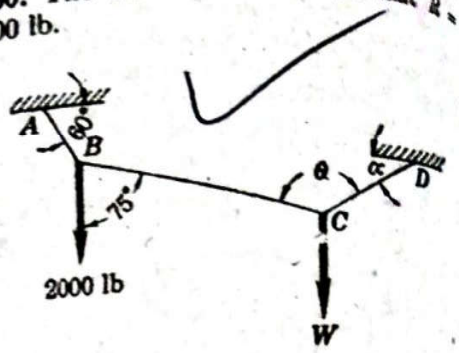


Fig. 46. Problems 91, 92.

91. Two weights are suspended from a flexible cable as shown in Fig. 46. For $\theta = 120°$, determine the internal forces in the various parts of the cable and the weight W. *Ans.* $AB = 2730$ lb., $BC = 1417$ lb., $CD = 1937$ lb., $W = 1736$ lb.

92. The same as **91** except that $\theta = 140°$.

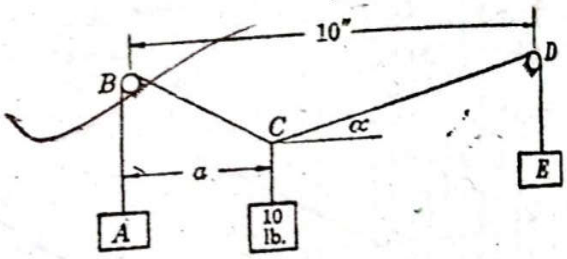


Fig. 47. Problems 93, 94.

93. A continuous string $ABCDE$, Fig. 47, passes over smooth pegs at B and D, 10 in. on centers. To the ends of the string are attached the weights $W_A = 7$ lb. and $W_E = 5$ lb. A 10-lb. weight is attached at C and the three bodies are in equilibrium. Determine the distance a and the angle α. *Ans.* 3.8 in., 49.5°.

94. The same as **93** except that $W_E = 10$ lb.

95. A weightless string is 10 ft. long and is attached to pins A and B, B being 6 ft. to the right of and 2 ft. below A. A weight is supported below the string by a frictionless ring. Determine the position of the ring on the string when the ring slides to the equilibrium position. (HINT: Study carefully the equilibrium condition in the horizontal direction.) *Ans.* 5 ft. below and 3.75 ft. to right of A

96. The same as **95** except that the string is 8 ft. long.

97. A timber ABC, Fig. 48, is supported by another timber DB. A load of F = 4.5 kips acts horizontally at C. If θ = 60°, find the reactions at A and B. Solve graphically and check by Lami's theorem. *Ans.* R_A = 14.74 kips, θ_A = 252.2°, R_B = 14.03 kips, θ_B = 90°.

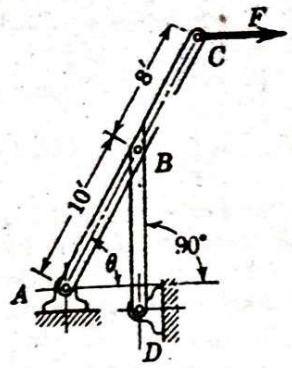


Fig. 48. Problems 97, 98.

98. The same as **97** except that θ = 40°.

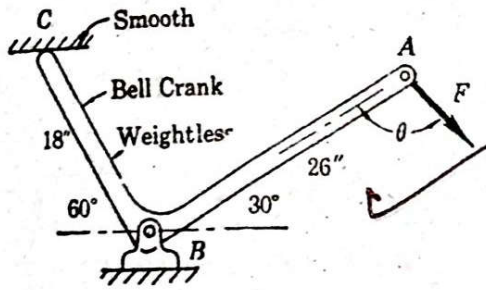


Fig. 49. Problems 99-101.

99. The bellcrank, Fig. 49, has a load F = 100 lb. If θ = 30°, solve graphically for the reactions at B and C.

100. The same as **99** except that θ = 90°. *Ans.* B = 379 lb. at 97.6°; C = 289 lb. at 270°.

101. The same as **99** except that θ = 120° with the positive x axis, determine θ and the reaction A graphically and algebraically. *Ans.* 54.6 lb., θ = 36.6°.

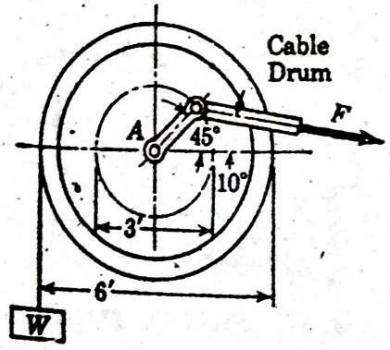


Fig. 50. Problem 102.

102. Figure 50 shows a cable drum which is turned by a steam engine. A pull of F = 9000 lb. is being exerted in the connecting rod to support a load W on the cable. By a graphical solution, find (a) W and (b) the bearing reaction at A. Check the result by the law of sines.

Ans. (a) 3690 lb., (b) 10,300 lb. at 140.4°.

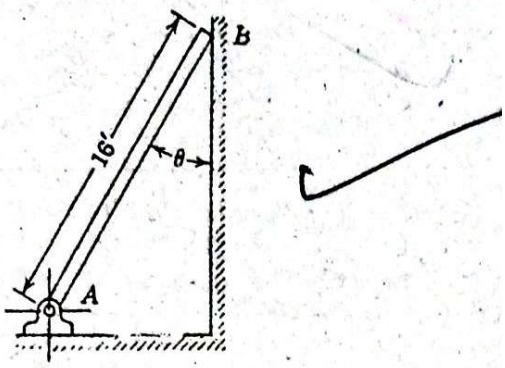


Fig. 51. Problems 103, 104.

103. The member AB, Fig. 51, weighs 2000 lb. and rests against a smooth wall at B. Determine graphically the reactions at B and A when θ = 30°. What are the horizontal and vertical components of the reaction at A?

Ans. B = 578 lb., A = 2084 lb., θ_A = 73.9°.

104. The same as **103** except that θ = 60°.

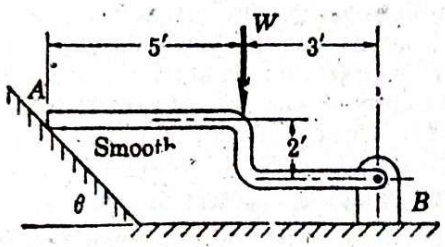


Fig. 52. Problems 105-108.

105. The bar AB in Fig. 52, with uniform cross section, is pivoted at pin B and rests on a smooth plane at A. If the bar weighs W = 100 lb. and if θ = 30°, find the pin reaction at B. Solve graphically and algebraically. *Ans.* 70 lb. at 105.7°.

106. The same as **105** except that θ = 60°.

107. In Fig. 52, the uniform bar weighs 100 lb. If the reaction at B is 65 lb. at 120° with the positive x axis, determine θ and the reaction A graphically and algebraically. *Ans.* 54.6 lb., θ = 36.6°.

108. The same as **107** except let B = 85 lb. at 150°.

109. In Fig. 53, the bodies A, weighing 50 lb., and B, weighing 75 lb., are connected by a cord and rest on smooth inclined planes. What is the angle θ if the bodies are in equilibrium? Solve algebraically and graphically.

Ans. 28.15°.

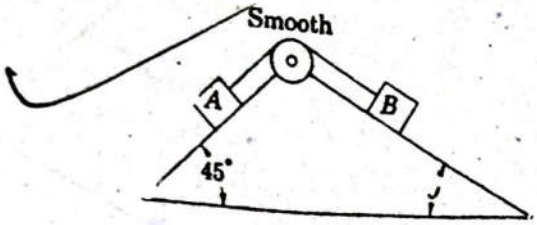


Fig. 53. Problems 109, 110.

110. The same as **109** except that B weighs 200 lb.

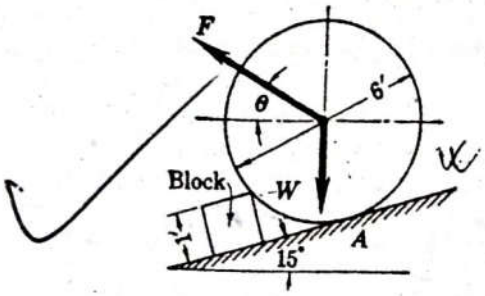


Fig. 54. Problems 111, 112.

111. The wheel of Fig. 54 is on the point of rolling over the block (that is, the reaction at A is zero, but the wheel has not moved). If $W = 1000$ lb., what is the magnitude and sense of the least force F that will produce this condition? Solve graphically.

Ans. 547 lb., $\theta = 33.2°$.

112. The same as **111** except that $W = 2$ kips. Solve algebraically and graphically.

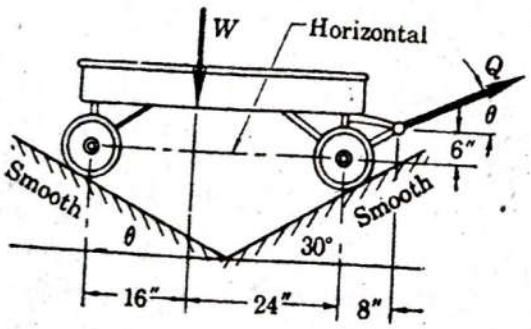


Fig. 55. Problem 113.

113. A boy's wagon is in process of crossing a ditch as shown in Fig. 55. If $W = 100$ lb., $Q = 0$, the wheels have a diameter of 10 in., and if the wagon is at rest, solve graphically for the normal reactions against the wheels and the value of angle θ. There is negligible friction.

Ans. $\theta = 21.2°$.

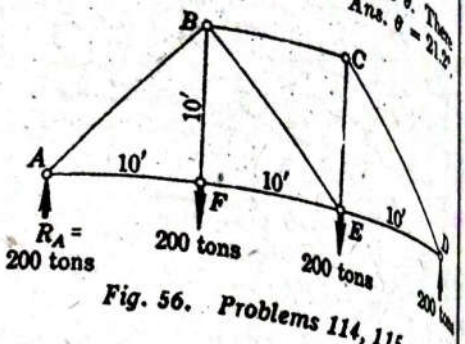


Fig. 56. Problems 114, 115.

114. In the bridge truss of Fig. 56, find the forces in members AB, AF, BF, and FE.

Ans. $AB = 283$ tons (C); $AF = 200$ tons (T); $BF = 200$ tons (T); $FE = 200$ tons (T).

115. In the bridge truss of Fig. 56, find the forces in members DC, DE, CE, BC, BE, and EF. Specify whether each member is in tension or compression.

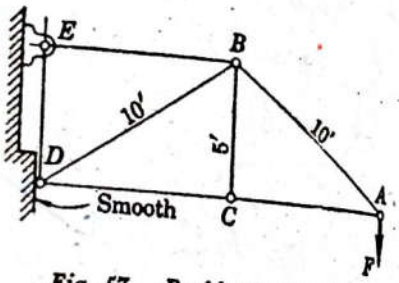


Fig. 57. Problems 116, 117.

116. (a) Find the forces on all members of the cantilever truss shown in Fig. 57 when $F = 4$ tons. (b) Using values found in the foregoing analysis, state the horizontal and vertical components of the pin reaction at E and state the directions in which they act to maintain the *truss* in equilibrium.

Ans. (b) $E_x = -13.88$ tons, $E_y = +4$ tons.

117. The same as **116** except that $F = 2.5$ kips.

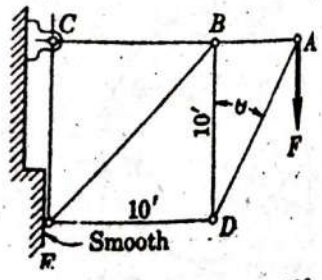


Fig. 58. Problems 118-120.

118. In Fig. 58, let $F = 10$ kips and $\theta = 30°$. Find the force in members AB and AD graphically and algebraically.