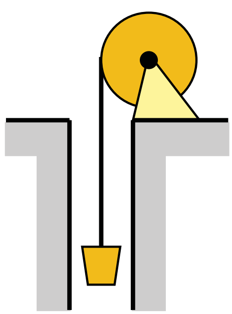
Problems: Chapter 1 – Chapter 16

Problems: Chapter 1 Opening Remarks

1.1 Rank the loads in order of magnitude, from highest to lowest: *Proof Load, Ultimate Load, Working Load.*

1.2 A drum-winch slowly lifts a large bucket full of ore from a mine. The ore has a density of 1600 kg/m^3. The bucket volume is 8.00 m^3. Neglect the mass of the bucket.

Determine **(a)** the mass of the ore supported by the cable, **(b)** the force in the cable in newtons, and **(c)** the force in pounds. **(d)** If the cable can support 500 kN, determine the Factor of Safety for this load.

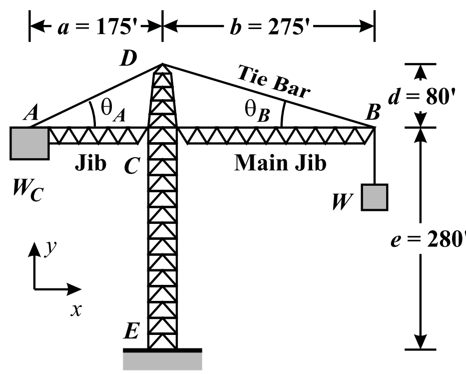


1.3 A residential structure (house) is built in New England. The size of the house is 2000 square feet, half of which is located on the second floor. The effective area of the roof is 1300 square feet. Since it is a residence, each floor must be designed to support a load of 40 psf. Due to snow, a load of 30 psf must be supported on the roof.

Considering the second-floor load and the snow load, determine the total load that the first floor walls must be designed to support.

1.4 The concrete counterweight of a large crane weighs W_C = 350,000 lb. Concrete has a weight density of γ = 150 lb/ft^3.

If the counterweight is approximately a cube, determine the length of each side **(a)** in feet, and **(b)** in meters.



1.5 At the end of Stearns Wharf in Santa Barbara, California, large wooden logs at the edge of the wharf are used as seats and as physical barriers between pedestrians and the ocean, 20 ft below. A typical log has a diameter of $2R$ = 2.5 ft and a length of 24 ft. The density of the wood is estimated to be 40 lb/ft^3.

Determine the minimum rating of the crane required to move the cylinders. Assume a Factor of Safety of 2.0, and that cranes come in 2000-lb increments (*i.e.*, 2000 lb, 4000 lb, 6000 lb, etc.)

1.6 A pressure vessel is designed to contain a working pressure of 45 MPa.

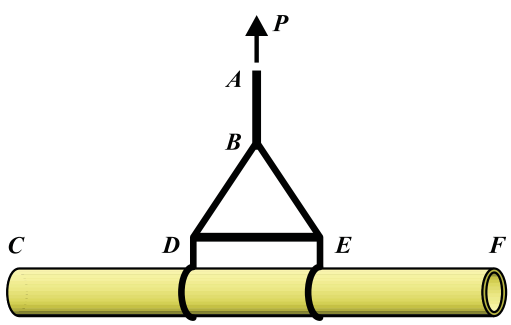
Per the A.S.M.E. Pressure Vessel Code, determine the minimum pressure required for a Proof Test.

1.7 The nominal strength of a production run of steel bars is 50 kN.

(a) If the working load is 20 kN, determine the Factor of Safety. **(b)** Your boss asks you to perform Proof Tests on a number of the bars at 60% above the Working Load. What fraction of the nominal strength is the Proof Load?

1.8 A crane slowly lifts a 30-ft length of 12-in. diameter standard pipe. Lift points *D* and *E* are 8.0 ft apart. A 12-in. standard steel pipe has an inside diameter of 12.0 in., a wall thickness of 0.375 in., and weighs 49.56 lb/ft (see ***Appendix D***).

(a) If the main strap *AB* that supports the pipe can support 10,000 lb, determine the Factor of Safety for this case. **(b)** Determine the weight density (lb/ft^3) of the pipe material.

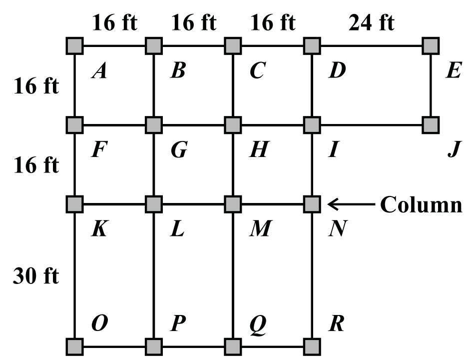


1.9 The plan (top) view of the second story of an *office building* is shown. Each support column (lettered) is represented by a shaded square, and the columns are arrayed in a rectangular grid pattern at varying distances. The lines between columns represent primary floor beams.

The load on each column can be approximated using a basic load-distribution model. The ***tributary area*** of each column – the area contributing to its load – is the area the column supports. Each column supports one-fourth of the rectangular area bound by it and the three other columns that form the rectangle. The total load on a single column is the product of the area load (psf) and the column's total tributary area (ft^2).

Floor loads for some building-types are given in ***Table 1-1*** of the text.

Determine **(a)** the load (force) on Columns *C*, *G*, and *I*, respectively, **(b)** the column(s) with the least load, and the value of the load, and **(c)** the column(s) with the greatest load, and the value of the load. **(d)** If this is a plan view of the second story of a *library stack room*, determine the load on column *G*.



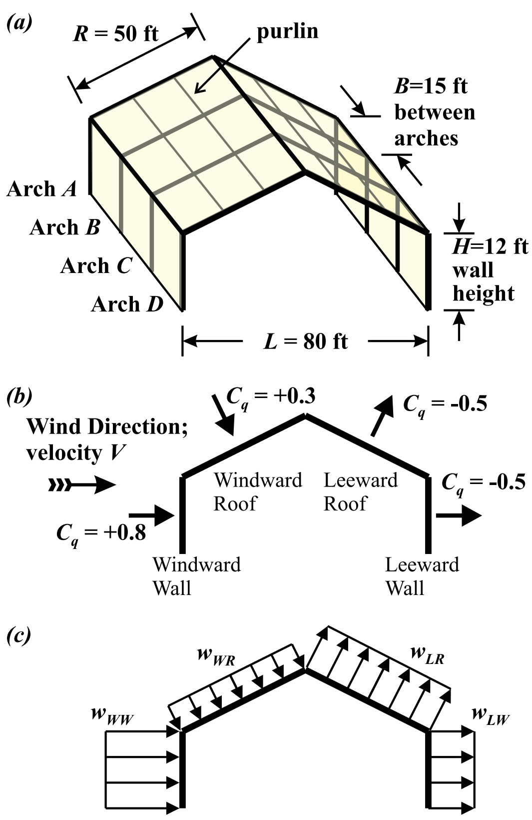
1.10 *Traditional wind-load analysis*. A steel frame building is constructed with four parallel *arches* or *frames*, *A-D*, separated by purlins (***Figure (a)***). The frames support the building *envelope* (the walls and roof). The span is $L = 80$ ft, the wall height is $H = 12$ ft, the arch spacing is $B = 15$ ft, and the half-roof length is $R = 50$ ft. The building is subjected to wind normal to the ridge line, with a velocity of $V = 70$ mph.

The equivalent *pressure* on any surface (wall or roof) due to the wind is given by:

$$p_i = C_q(0.00256V^2)$$

where p_i is in pounds per square foot (psf) and V is in mph. The variable C_q depends on the building surface, and is defined for a particular case by ***Figure (b)***. A positive C_q means the pressure acts against the surface, a negative value means the pressure acts away from the surface (suction).

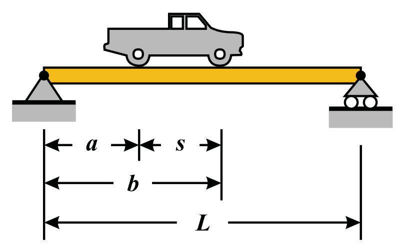
Determine **(a)** the total force on the entire left (windward) wall of the structure, and **(b)** the total load on the right-half (leeward) roof. **(c)** Determine the distributed line load *w* (lb/ft) that acts on each segment of *Arch C* – the windward wall, the windward roof, the leeward roof and the leeward wall. Draw the distributed load pattern with values and units on a 2-d sketch of *Arch C* (*e.g.*, ***Figure (c)***). Draw the distributed loads proportional to their values.



Hint: The load on each arch segment (wall or roof) can be estimated using a basic load-distribution model. The ***tributary area*** on each arch segment – the area contributing to its load – is half the wall or roof area that the arch segment shares with the neighboring arch(es). The product of the appropriate pressure and the segment's tributary area is the total load (force) on each segment (*e.g.*, the load on the windward roof of Arch *C*). This load acts uniformly over the length of the segment.

1.11 A 16.0-kN truck (including its load) is stopped on a bridge. The bridge is L = 14.0 m long, and the truck's wheelbase is s = 4.0 m. Assume that the weight of the truck is evenly distributed between the front and rear axles. The rear of the truck is a = 4.0 m from the left end of the bridge.

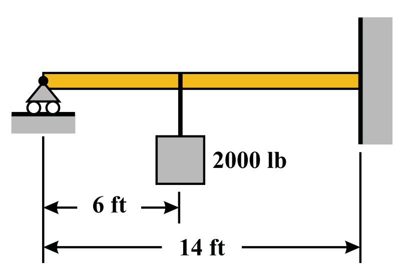
Model the bridge: create a free body diagram including the reactions at the supports Do not solve for the reactions.



1.12 A 2000-lb weight hangs from a 14-ft long beam. The beam is supported by a roller at the left end, and is built-in to the wall at the right end.

Model the beam: create a free body diagram including the reactions at the supports Do not to solve for the reactions.

Note: this is an indeterminate system; it cannot be solved using statics alone.

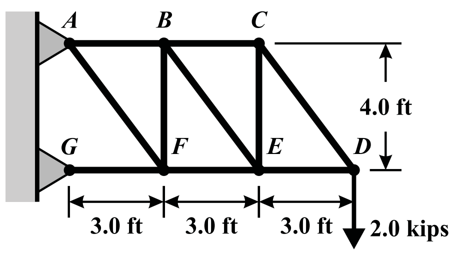


Problems: Chapter 2 Statics

2.1 Axial Members

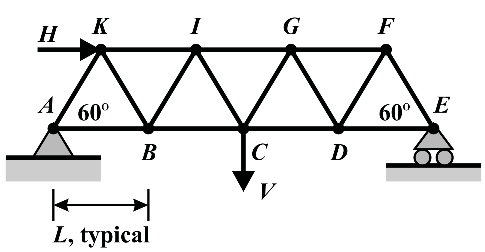
2.1 A cantilever truss supports a point load at Joint *D*.

Calculate the forces in members *CD*, *BC*, *BE* and *FE*. Assume all member forces are in tension so that a positive value indicates *tension* (T) and a negative value indicates *compression* (C).



2.2 All of the members of simply-supported truss *AE* are $L = 3.0$ m long. Forces $H = 10.0$ kN and $V = 20.0$ kN are applied as shown.

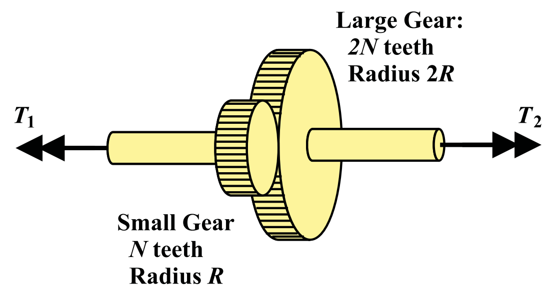
Calculate the force in members *AB*, *BC*, *IC*, and *IG*. Assume all member forces are in tension so that a positive value indicates *tension* (T) and a negative value indicates *compression* (C).



2.2 Torsion Members

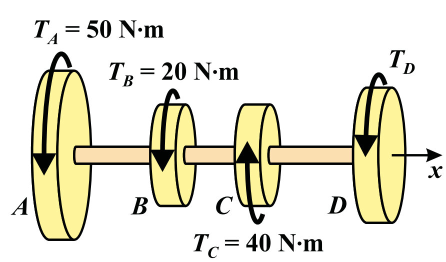
2.3 A set of gears transfers torque from one shaft to another.

If the radius of the large gear is twice the radius of the small gear, determine the ratio of the torques, T_2 to T_1.



2.4 A shaft has four gears, *A*, *B*, *C* and *D* (shown without gear teeth). Gears *A* through *C* are subjected to torques T_A, T_B and T_C, acting as shown.

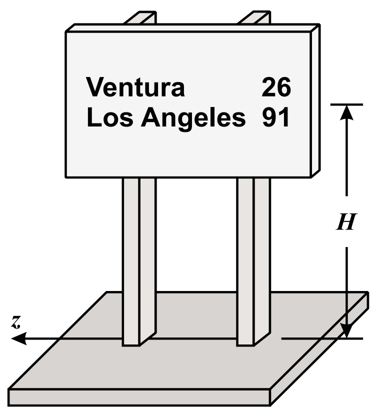
(a) If the system is in equilibrium, determine the torque on Gear *D*, T_D. Write the answer as positive or negative with respect to the curved arrow shown. **(b)** Determine the torque supported inside the shaft between gears *A* and *B*, T_{AB}, between *B* and *C*, T_{BC}, and between *C* and *D*, T_{CD}.



2.3 Beams

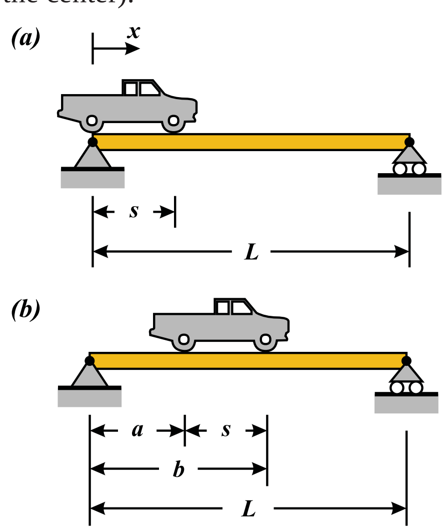
2.5 The face of a highway sign, 10 ft wide by 6.0 ft tall, is acted on by a uniform wind pressure of 10 psf (perpendicular to the sign). The center of the sign is $H = 8.0$ ft above the ground. Two symmetrically-placed posts support the sign. The posts are positioned in such a way that the wind load does not cause them to twist.

Calculate the magnitude of the shear force and moment reactions on each post at the ground (due to symmetry of the geometry and of the load, the reaction of the ground on both posts is the same).



2.6 A 16.0-kN truck (including its load) slowly crosses a bridge that is modeled as a simply-supported beam. The bridge is L = 14.0 m long, and the truck's wheelbase is s = 4.0 m. Assume that the weight of the truck is evenly distributed between the front and rear axles.

Draw the shear and moment diagrams for the beam, and determine the maximum moment **(a)** when the rear axle just reaches the bridge (left support), and **(b)** when the rear axle is a = 5.0 m from the left support (*i.e.*, the truck is at the center).

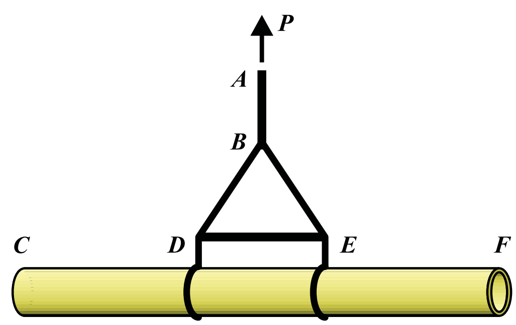


2.7 Consider the truck and bridge of ***Prob. 2.6***.

Determine **(a)** the value of a that gives the largest moment as the truck crosses the bridge, and **(b)** magnitude of that moment. *Hint*: it is not when the truck is at the center of the beam.

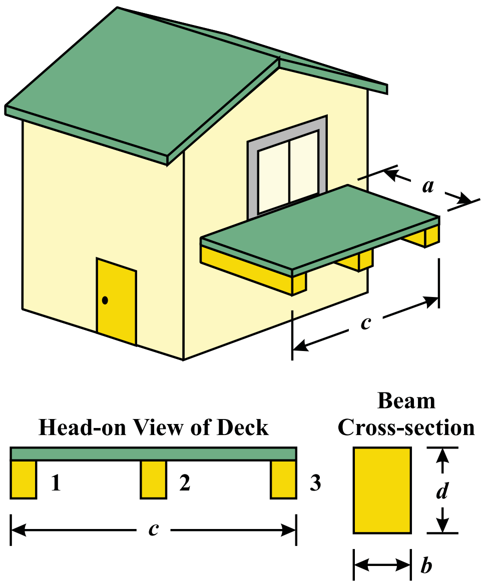
2.8 A crane slowly lifts a 30-ft length of 12-in. diameter standard pipe that weighs 49.56 lb/ft. Lift points D and E are 8.0 ft apart.

(a) Draw the shear and moment diagram of the pipe. **(b)** Determine the maximum bending moment in the pipe.



2.9 You are designing a deck for a house outside of Chicago, Illinois. The deck is c = 12 ft wide by a = 6.0 ft deep, and is supported by three beams as shown. The ground snow load around Chicago is 30 psf.

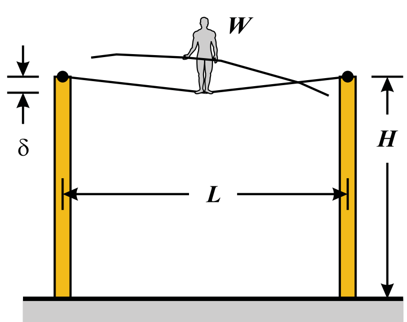
Determine **(a)** the total snow load (force) on the deck assuming the deck load is the same as the ground load, **(b)** the uniformly distributed load, w, on each beam, Beam 1, 2 and 3 (*hint*: what fraction of the deck does each beam support, assuming the deck remains level?), and **(c)** the magnitude of the maximum bending moment in the center beam (Beam 2).



2.4 Combined Loading

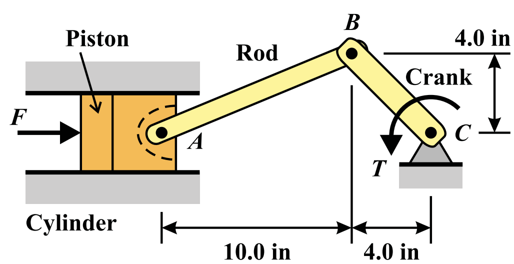
2.10 A tight-rope walker weighs $W = 160$ lb. He walks on a rope $H = 20.0$ ft above the ground. The rope spans two poles that are $L = 30.0$ ft apart. When he reaches the center, the rope is taut and has deflected $\delta = 1.0$ ft.

Determine the horizontal and vertical reaction forces and the reaction moment at the base of the left pole.



2.11 The *piston*, *connecting rod* (AB) and *crank* (BC) of an engine system are pinned together as shown. As the piston moves left-and-right, the crank rotates and provides torque T about an axis (out of the paper) at Shaft C (the resisting torque is shown). Rod AB is a two-force member. Assume there is no friction between the piston and its cylinder. At the instant shown, the force acting on the piston from the gas pressure is $F = 3.0$ kips.

Determine **(a)** the force in rod AB, and **(b)** the magnitude of the torque about the C-axis. **(c)** Determine the normal force on the cylinder. Is it upward or downward?



2.12 A boom is subjected to downward force F. The load and geometry are: $F = 400$ N, $a = 8.0$ m, $b = 2.0$ m, $D = 100$ mm.

Determine the reactions at cross-section ABC.