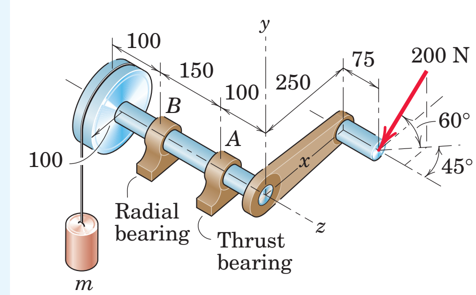
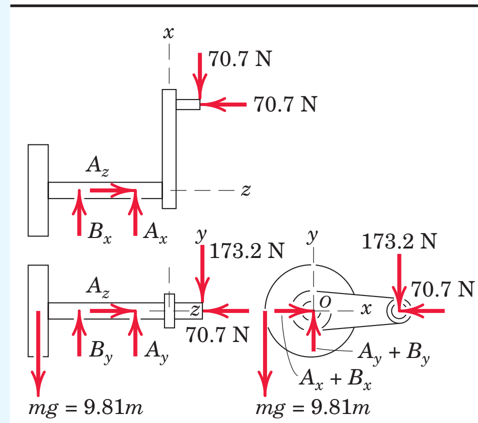
SAMPLE PROBLEM 3/6

A 200-N force is applied to the handle of the hoist in the direction shown. The bearing A supports the thrust (force in the direction of the shaft axis), while bearing B supports only radial load (load normal to the shaft axis). Determine the mass m which can be supported and the total radial force exerted on the shaft by each bearing. Assume neither bearing to be capable of supporting a moment about a line normal to the shaft axis.



Dimensions in millimeters



Solution. The system is clearly three-dimensional with no lines or planes of symmetry, and therefore the problem must be analyzed as a general space system of forces. A scalar solution is used here to illustrate this approach, although a solution using vector notation would also be satisfactory. The free-body diagram of the shaft, lever, and drum considered a single body could be shown by a space view if desired, but is represented here by its three orthogonal projections. (1)

The 200-N force is resolved into its three components, and each of the three views shows two of these components. The correct directions of A_x and B_x may be seen by inspection by observing that the line of action of the resultant of the two 70.7-N forces passes between A and B. The correct sense of the forces A_y and B_y cannot be determined until the magnitudes of the moments are obtained, so they are arbitrarily assigned. The x-y projection of the bearing forces is shown in terms of the sums of the unknown x- and y-components. The addition of A_z and the weight $W = mg$ completes the free-body diagrams. It should be noted that the three views represent three two-dimensional problems related by the corresponding components of the forces.

(2) From the x-y projection:

$[\Sigma M_O = 0]$ $\quad 100(9.81m) - 250(173.2) = 0 \qquad m = 44.1 \text{ kg}$ *Ans.*

From the x-z projection:

$[\Sigma M_A = 0]$ $\quad 150B_x + 175(70.7) - 250(70.7) = 0 \qquad B_x = 35.4 \text{ N}$

$[\Sigma F_x = 0]$ $\quad A_x + 35.4 - 70.7 = 0 \qquad A_x = 35.4 \text{ N}$

(3) The y-z view gives

$[\Sigma M_A = 0]$ $\quad 150B_y + 175(173.2) - 250(44.1)(9.81) = 0 \qquad B_y = 520 \text{ N}$

$[\Sigma F_y = 0]$ $\quad A_y + 520 - 173.2 - (44.1)(9.81) = 0 \qquad A_y = 86.8 \text{ N}$

$[\Sigma F_z = 0]$ $\quad A_z = 70.7 \text{ N}$

The total radial forces on the bearings become

$[A_r = \sqrt{A_x{}^2 + A_y{}^2}]$ $\quad A_r = \sqrt{(35.4)^2 + (86.8)^2} = 93.5 \text{ N}$ *Ans.*

(4) $[B = \sqrt{B_x{}^2 + B_y{}^2}]$ $\quad B = \sqrt{(35.4)^2 + (520)^2} = 521 \text{ N}$ *Ans.*

Helpful Hints

1. If the standard three views of orthographic projection are not entirely familiar, then review and practice them. Visualize the three views as the images of the body projected onto the front, top, and end surfaces of a clear plastic box placed over and aligned with the body.

2. We could have started with the x-z projection rather than with the x-y projection.

3. The y-z view could have followed immediately after the x-y view since the determination of A_y and B_y may be made after m is found.

4. Without the assumption of zero moment supported by each bearing about a line normal to the shaft axis, the problem would be statically indeterminate.