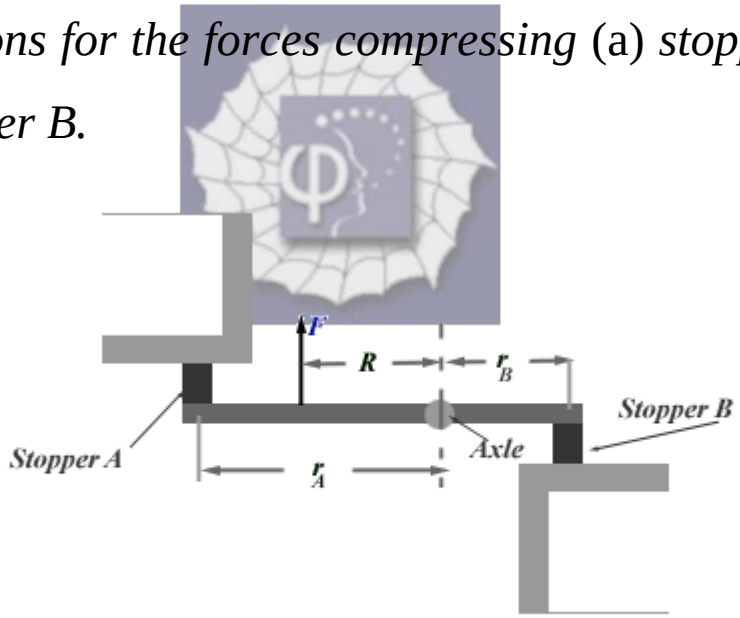
59.

Problem 13.56P (HRW)

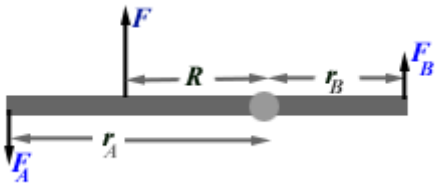
A rigid body can turn around a vertical axis until it presses against identical rubber stoppers A and B attached to rigid walls at distances r_A *and* r_B *from the axle. Initially the stoppers touch the walls, without being compressed. Then force F is applied perpendicular to the rod at a distance R from the axle. We have to find expressions for the forces compressing* (a) *stopper A and* (b) *stopper B.*



Solution:

We draw free-body diagram of the rod. When the rod presses against the stopper *A* it will experience force F_A acting on it in the anti-clockwise direction and force F_B acting on it in the clockwise direction as it compresses

the stopper *B.* According to Newton's third law of motion the magnitude of forces compressing stoppers *A* and *B* will be F_A and F_B. Conditions of static and rotational equilibrium will give algebraic equations that can be solved for F_A and F_B.



For static equilibrium the vector sum of forces acting on the rod has to be zero. That is

$$F + F_B = F_A.$$

And, the condition of rotational equilibrium is that the vector sum of torques about the axle has to be zero. That is

$$FR = F_A r_A + F_B r_B.$$

Solving these equations for F_A and F_B, we find

$$F_A = \frac{F\left(R + r_B\right)}{r_A + r_B},$$

and

$$F_B = \frac{F\left(R - r_A\right)}{r_A + r_B}.$$