Lecture # 6

Knuckle Joint

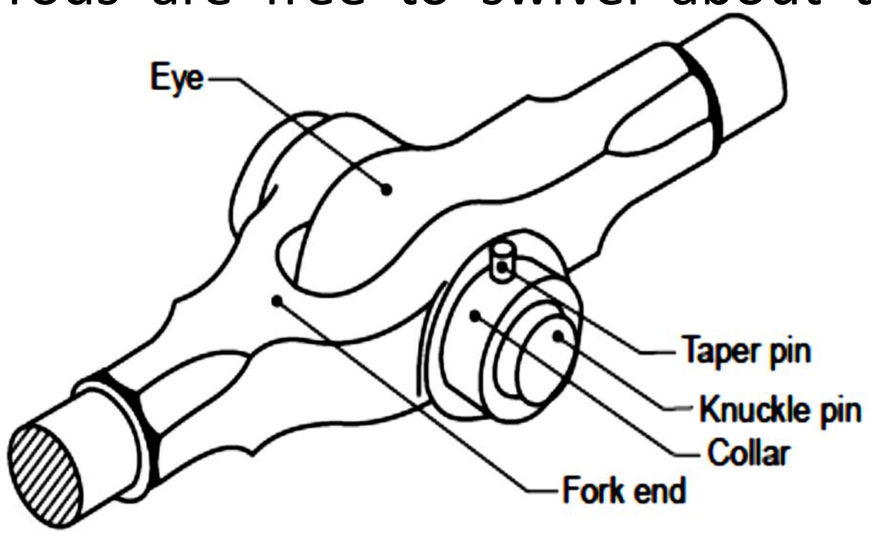
Knuckle Joint

A knuckle joint is a pin joint used to fasten two circular rods.

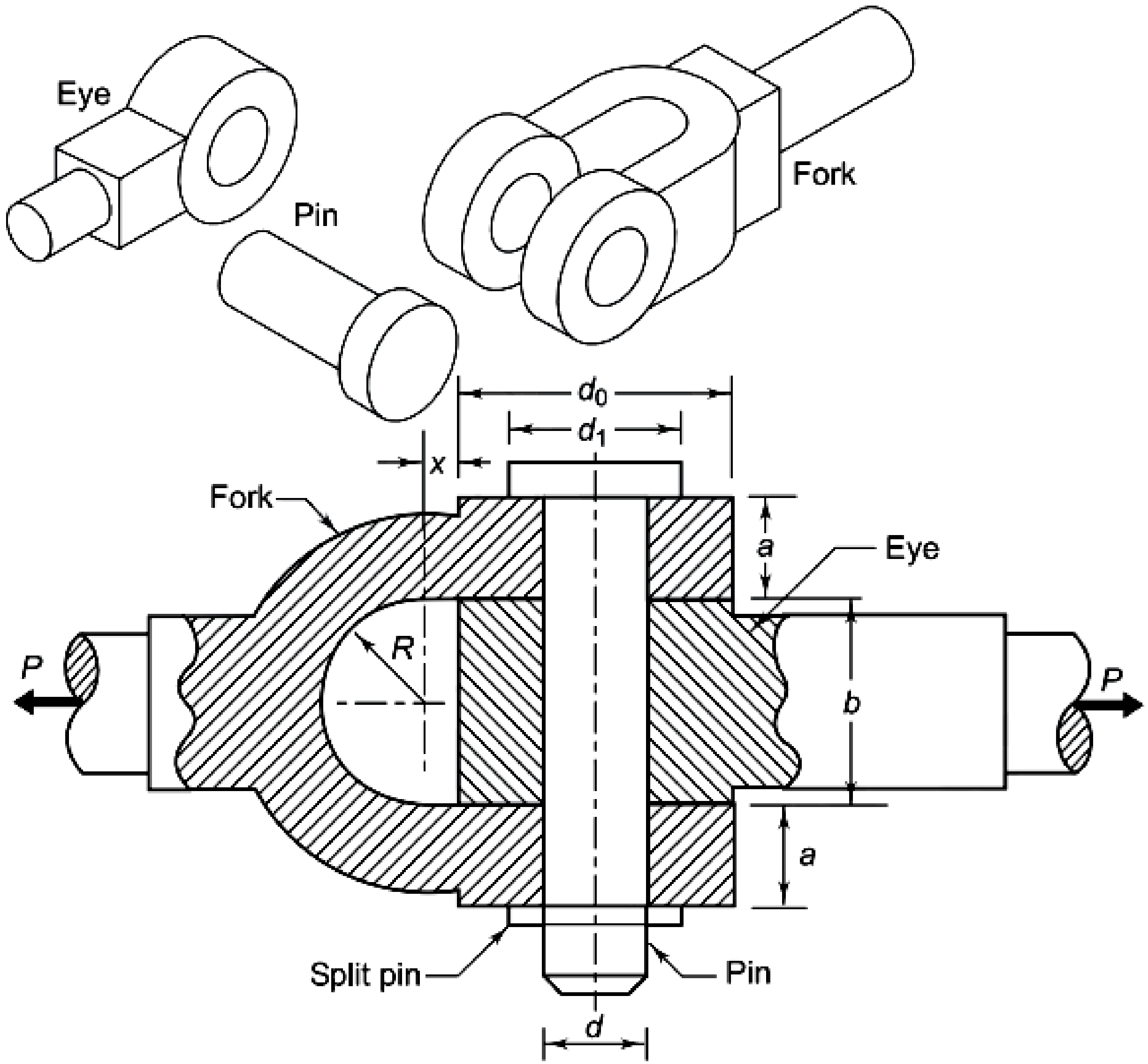
In this joint, one end of the rod is formed into an eye and the other into a fork (double eye).

For making the joint, the eye end of the rod is aligned into the fork end of the other and then the pin is inserted through the holes and held in position by means of a collar and a taper pin.

Once the joint is made, the rods are free to swivel about the cylindrical pin.



Knuckle Joint



Knuckle Joint

Some of the Applications of Knuckle Joint

Air brake arrangement of locomotives.

Joints between the tie bars in roof trusses.

Joints between the links of a suspension bridge.

Joints in valve mechanism of a reciprocating engine.

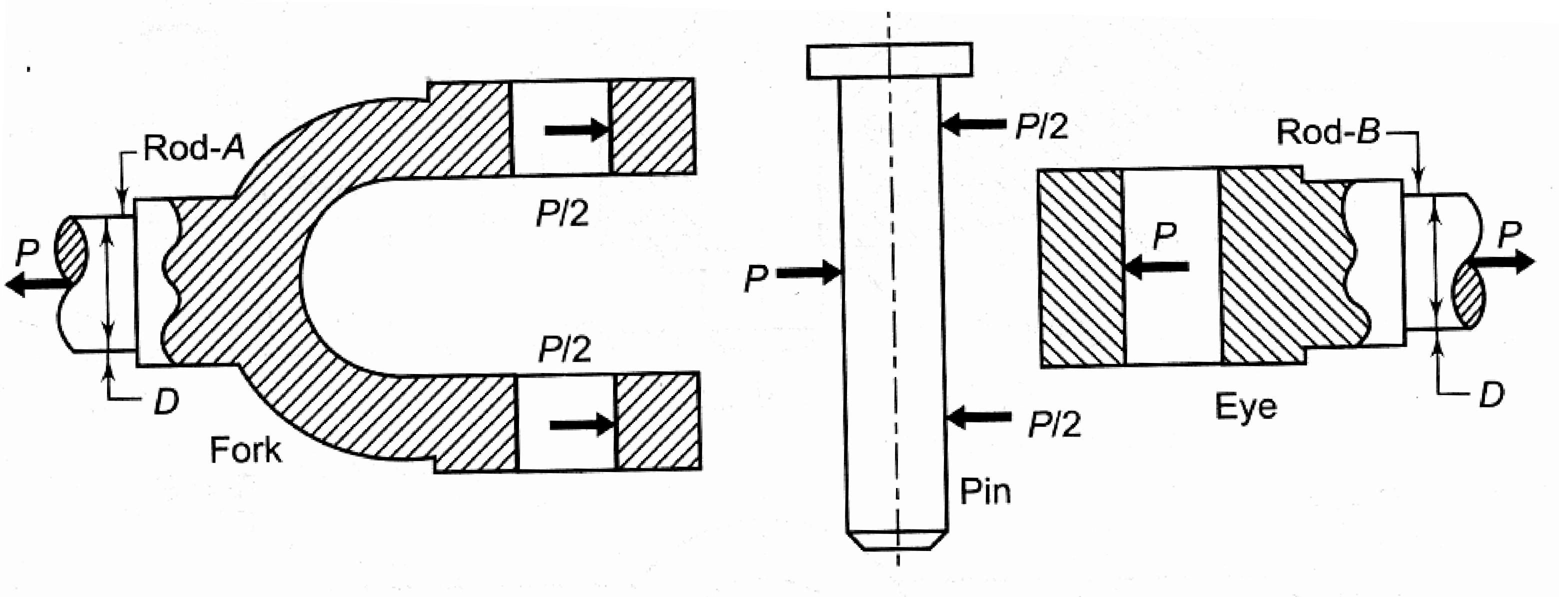
Fulcrum for the levers.

Joints between the links of a bicycle chain.

Knuckle Joint

Design of a Knuckle joint

It is assumed that the material for the rods and pins is same and the allowable stresses in tension, compression and shear are given by σ_t, σ_c and τ.

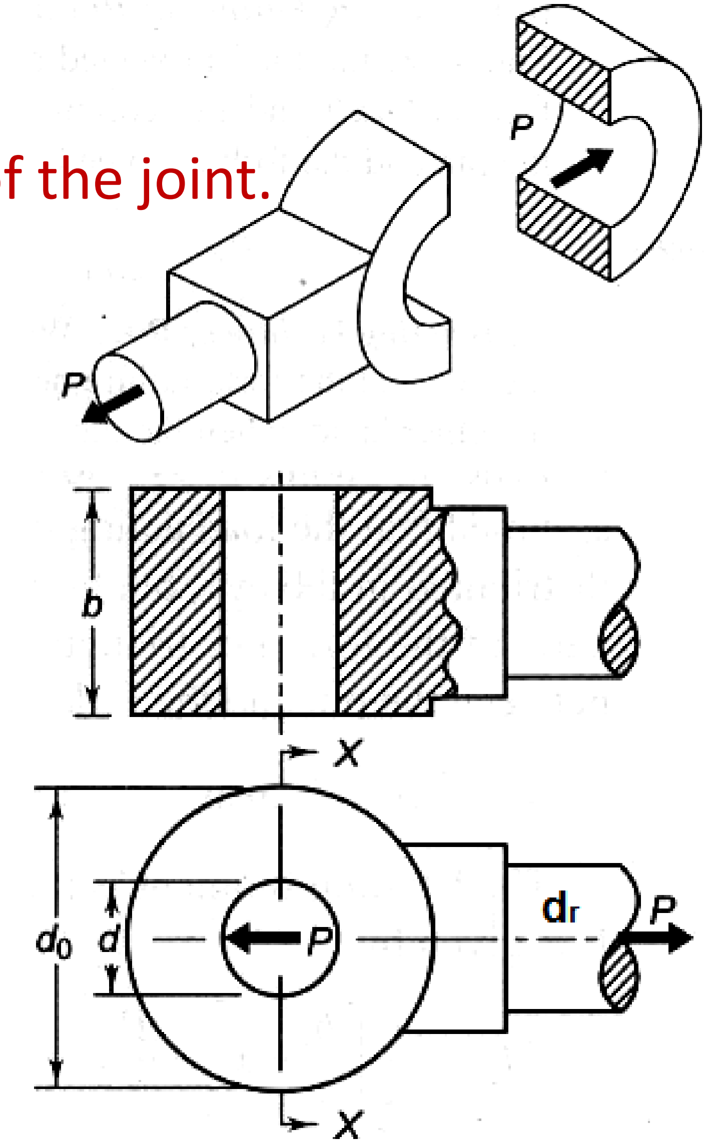


Free Body Diagram of Forces

Knuckle Joint

Design of a Knuckle joint

The Following are the failures analysis of the joint.



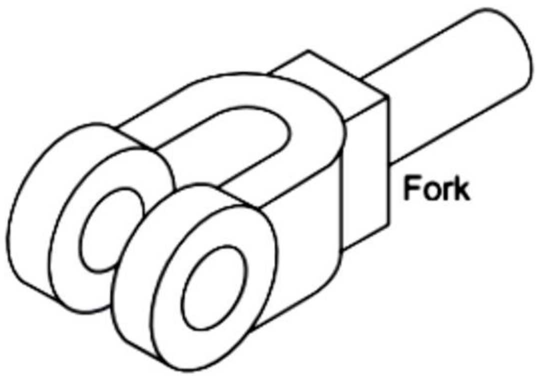
1. Tension failure of rod

$$\frac{\pi}{4} d_r \sigma_t = P$$

2. Tension failure of eye end

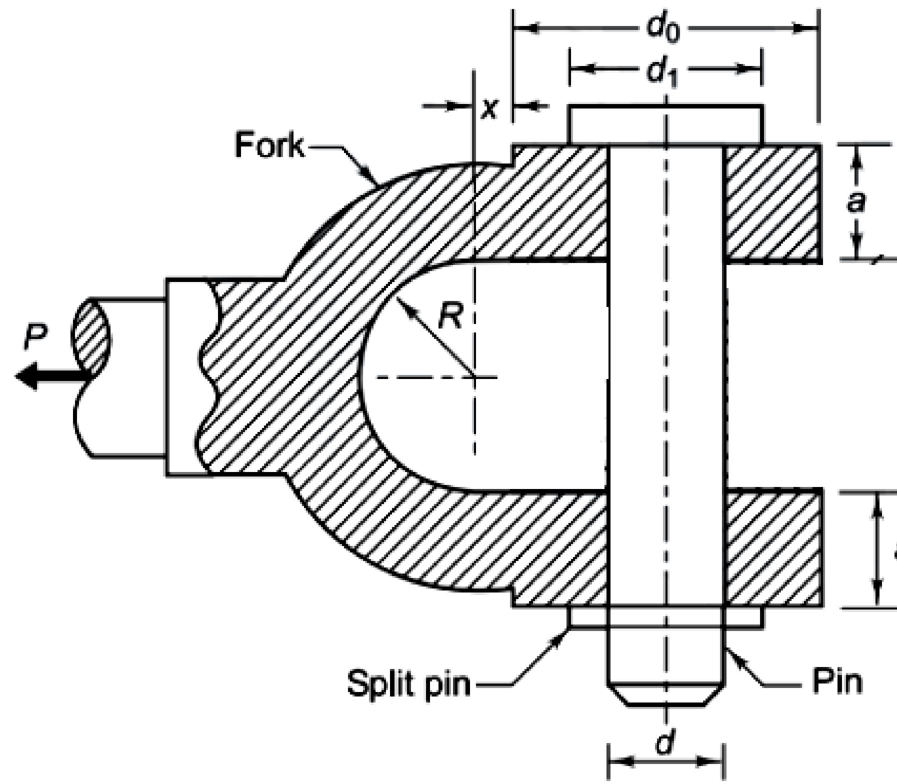
$$b(d_0 - d)\sigma_t = P$$

Design of a Knuckle joint



3. Tension failure of fork end

$$2a(d_0 - d)\sigma_t = P$$



Knuckle Joint

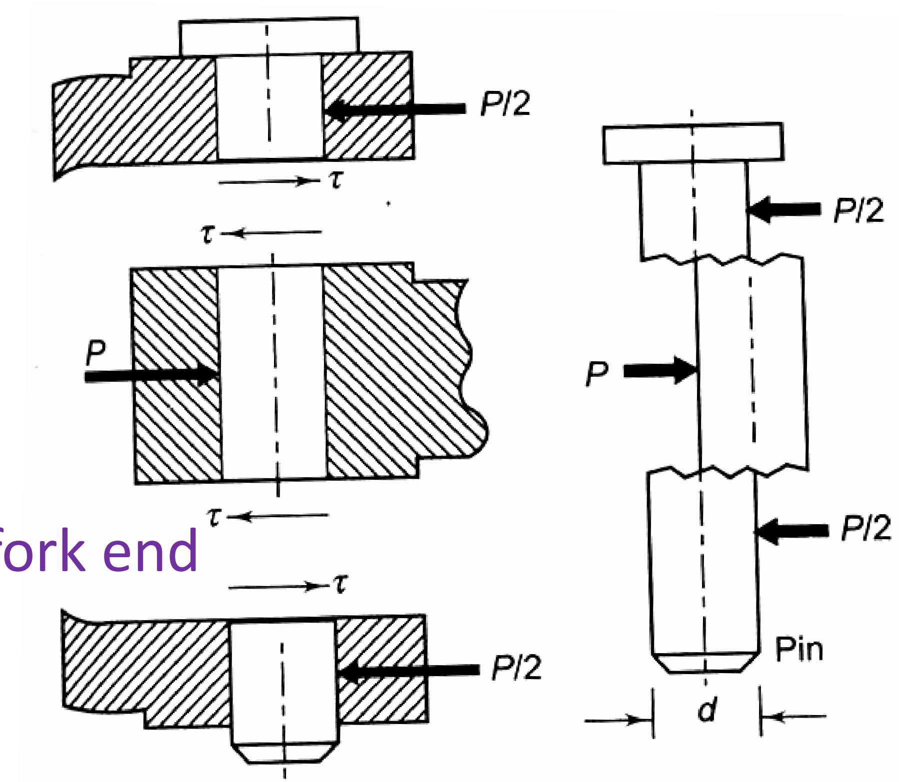
Design of a Knuckle joint

4. Shear failure of pin

$$2\left(\frac{\pi}{4}d^2\right)\tau = P$$

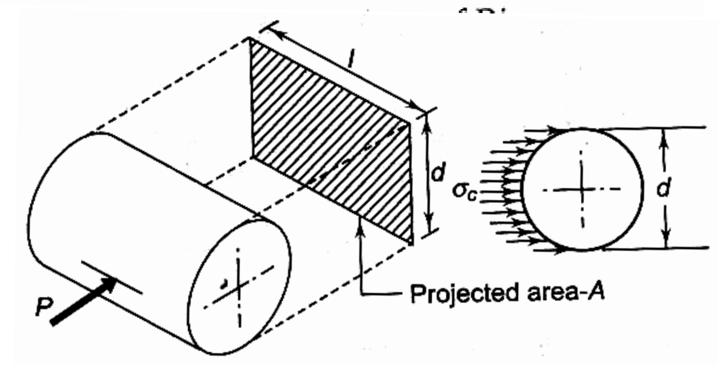
5. Compression failure of pin in fork end

$$2ad\sigma_c = P$$



6. Compression failure of pin in eye end

$$bd\sigma_c = P$$

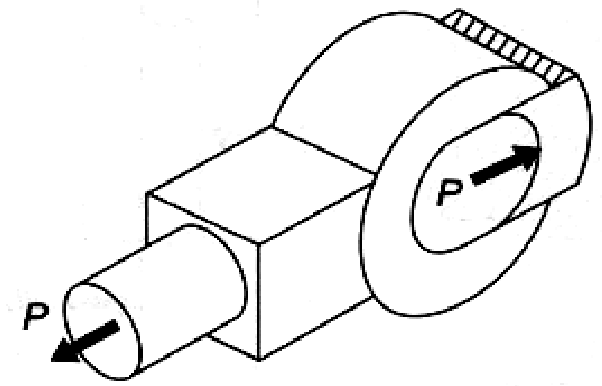


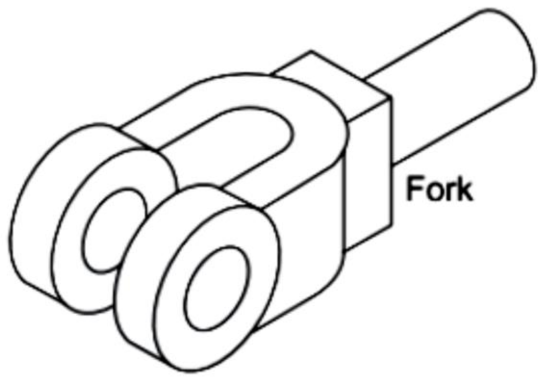
Knuckle Joint

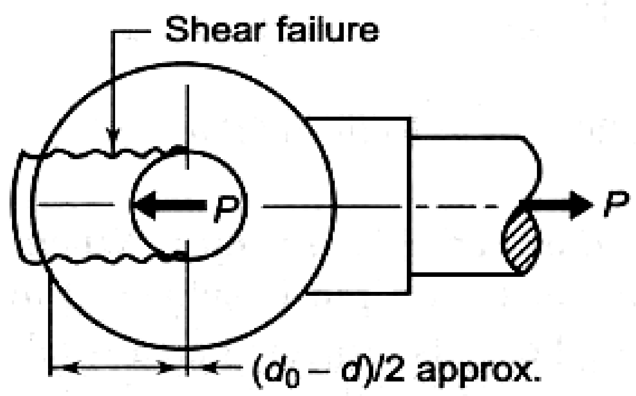
Design of a Knuckle joint

7. Shear failure of eye end

$$b(d_0 - d)\tau = P$$







8. Shear failure of frok end

$$2a(d_0 - d)\tau = P$$

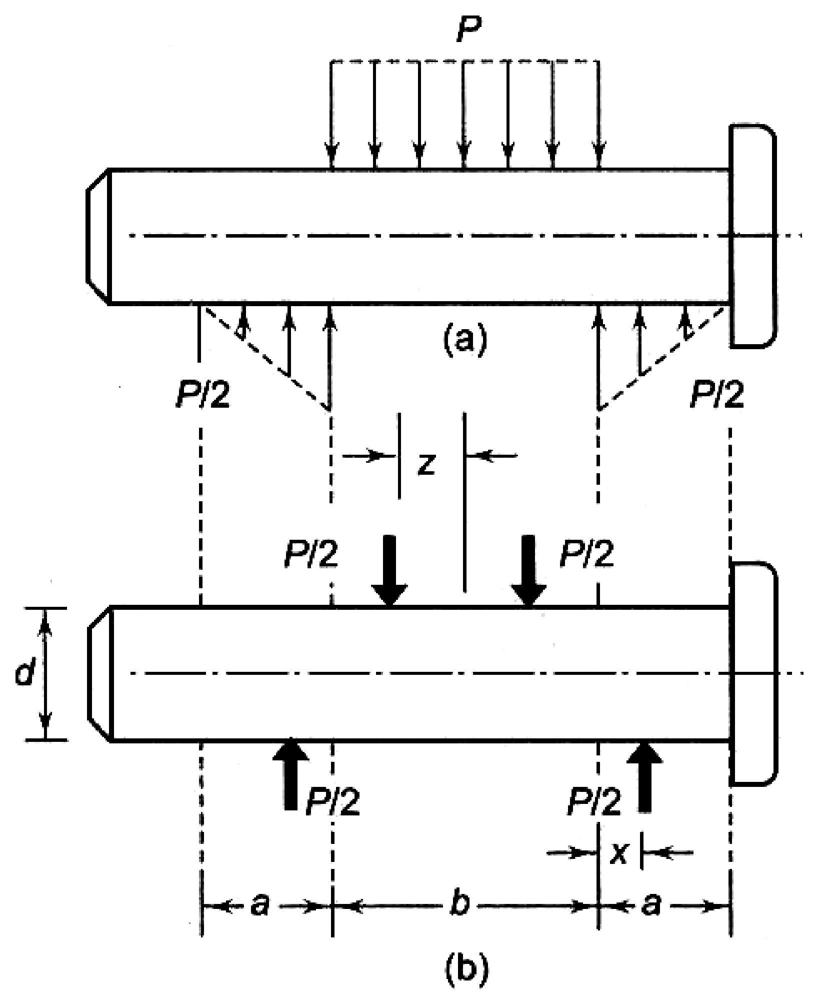
Knuckle Joint

Design of a Knuckle joint

9. Bending failure of pin

It is assumed that the load acting on the pin is uniformly distributed in the eye, but uniformly varying in two parts of the fork.

For triangular distribution of load between the pin and the fork,



Pin Treated as Beam (a) Actual Distribution of Forces (b) Simplified Diagram of Forces

Design of a Knuckle joint

9. Bending failure of pin

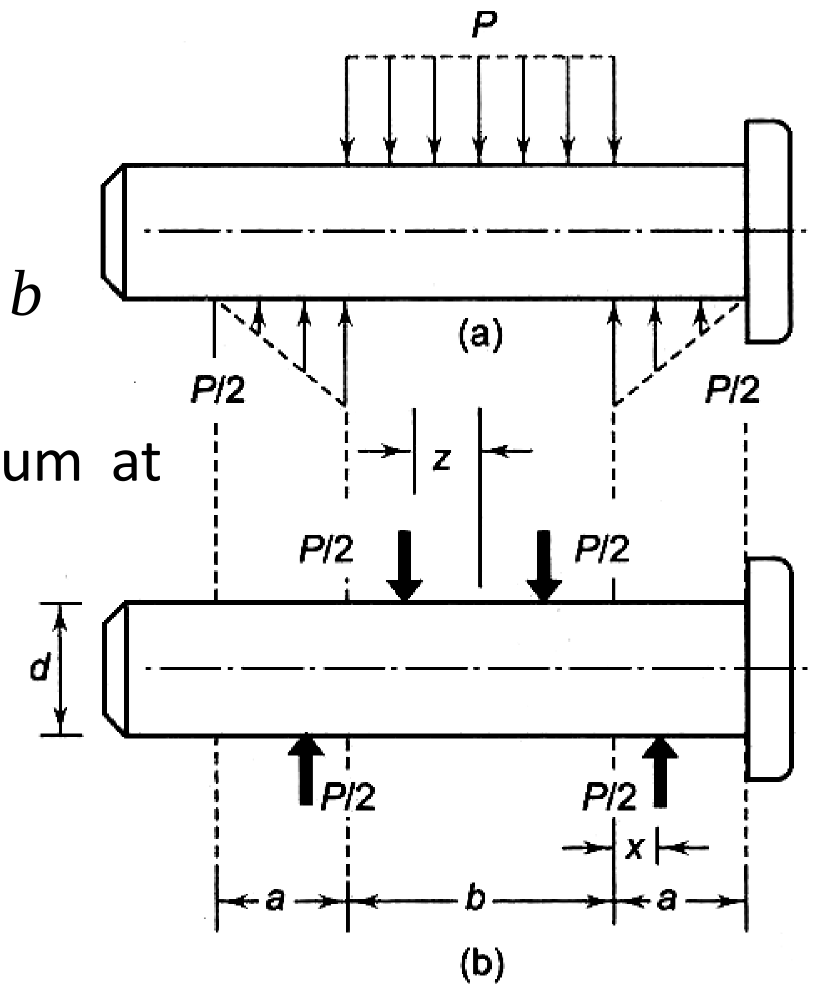
$$x = \frac{1}{3}a \quad \text{also} \quad z = \frac{1}{2}\left(\frac{1}{2}b\right) = \frac{1}{4}b$$

The bending moment is maximum at the centre. It is given by,

$$M_b = \frac{P}{2}\left[\frac{b}{2} + x\right] - \frac{P}{2}(z)$$

$$M_b = \frac{P}{2}\left[\frac{b}{2} + \frac{a}{3}\right] - \frac{P}{2}\left[\frac{b}{4}\right]$$

$$M_b = \frac{P}{2}\left[\frac{b}{4} + \frac{a}{3}\right]$$



Pin Treated as Beam (a) Actual Distribution of Forces (b) Simplified Diagram of Forces

Knuckle Joint

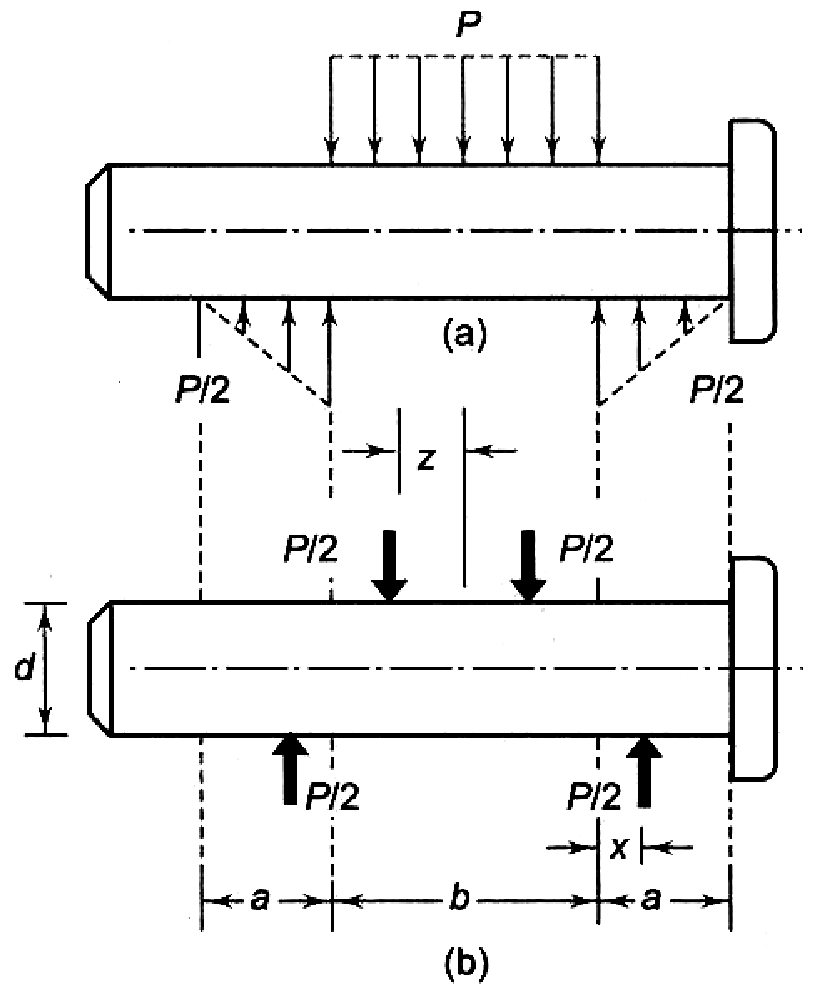
Design of a Knuckle joint

9. Bending failure of pin

$$Also,\ I = \frac{\pi d^4}{64} \quad \text{and} \quad y = \frac{d}{2}$$

therefore

$$\sigma_b = \frac{M_b y}{I} = \frac{\frac{P}{2}\left[\frac{b}{4} + \frac{a}{3}\right]\frac{d}{2}}{\frac{\pi d^4}{64}}$$



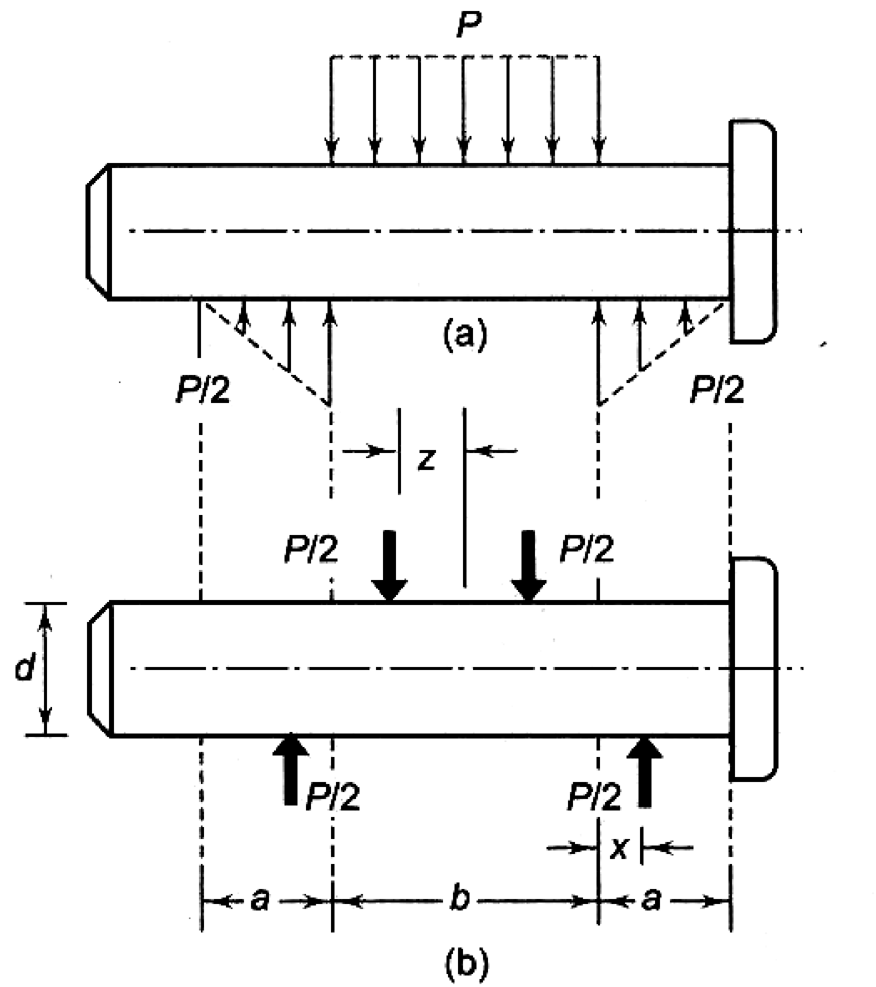
Pin Treated as Beam (a) Actual Distribution of Forces (b) Simplified Diagram of Forces

Design of a Knuckle joint

9. Bending failure of pin

$$\sigma_b = \frac{32}{\pi d^3} \times \frac{P}{2}\left[\frac{b}{4} + \frac{a}{3}\right]$$

$$\sigma_b = \frac{16P}{\pi d^3}\left[\frac{b}{4} + \frac{a}{3}\right]$$



Pin Treated as Beam (a) Actual Distribution of Forces (b) Simplified Diagram of Forces

Knuckle Joint

Problem 1

Design a Knuckle joint to connect two steel rods circular in cross section to carry an axial pull of 40kN. All the components of the joint are to be made of steel.

References

ABDULLA SHARIF, Design of Machine Elements, Dhanpat Rai Publications (P) Ltd, New Delhi, 1995.

V. B. Bhandari, Design of Machine Elements, Third Ed., The McGraw-Hills Companies, New Delhi

R. S. KHURMI and J.K.GUPTA, A Text Book of Machine Design, S.Chand and company ltd., New Delhi, 2000.

http://www.nptel.iitm.ac.in

https://machinedesign.top/content/Introduction%20to%20Machine%20Design