

Lecture # 6

Knuckle Joint

2/4/2026

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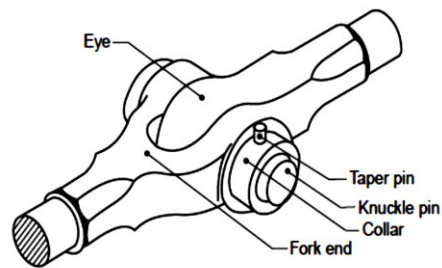
Knuckle Joint

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.



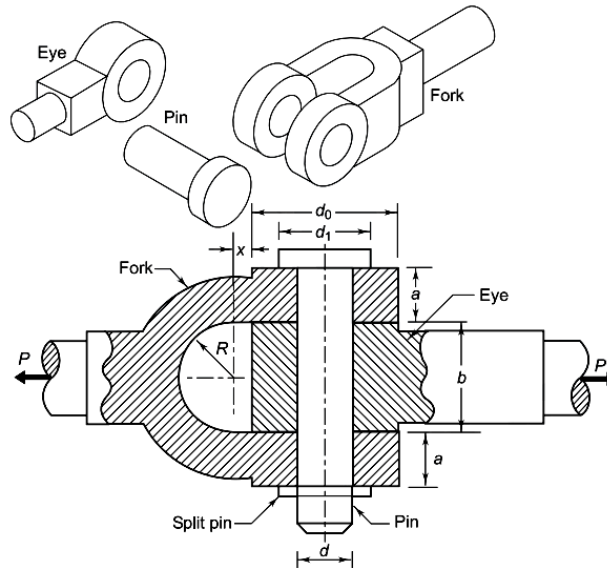
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Knuckle Joint

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.

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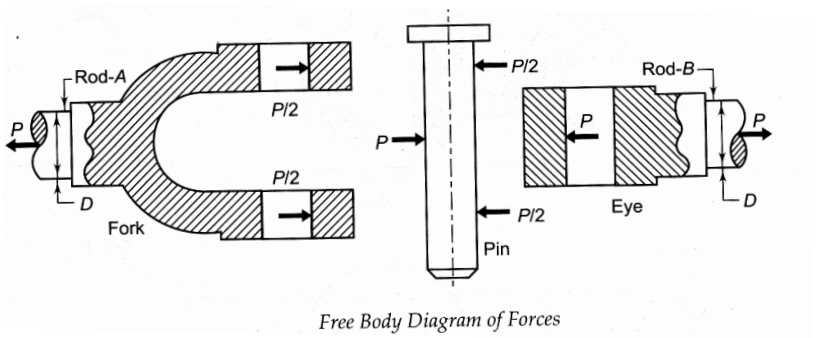
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Knuckle Joint

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 .



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Knuckle Joint

Design of a Knuckle joint

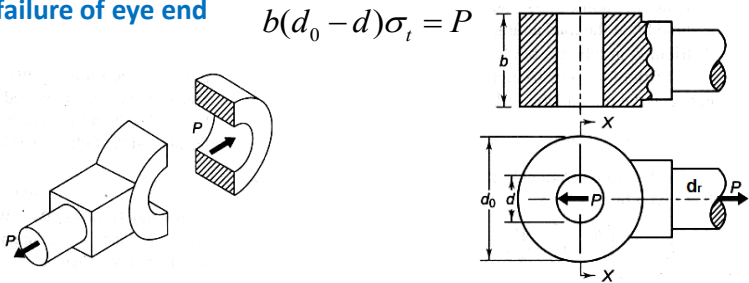
The Following are the failures analysis of the joint.

1. Tension failure of rod

$$\frac{\pi}{4} d^2 \sigma_t = P$$

2. Tension failure of eye end

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



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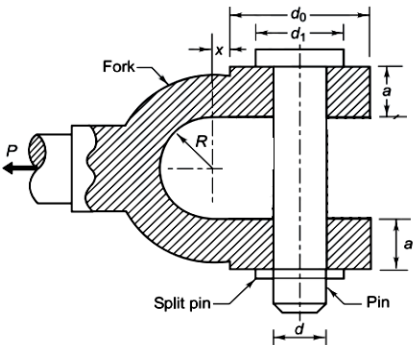
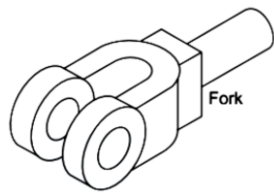
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3. Tension failure of fork end

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

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4. Shear failure of pin

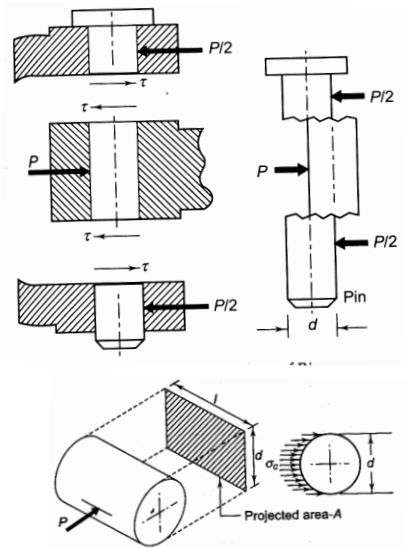
$$2 \left(\frac{\pi}{4} d^2 \right) \tau = P$$

5. Compression failure of pin in fork end

$$2ad\sigma_c = P$$

6. Compression failure of pin in eye end

$$bd \sigma_c = P$$

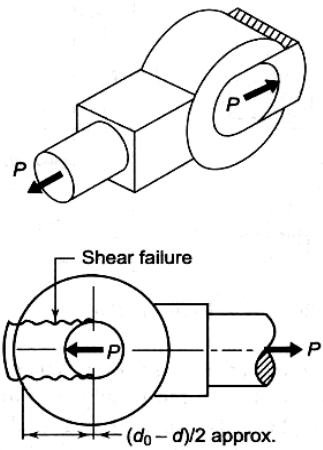
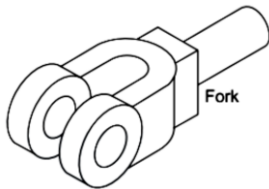


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7. Shear failure of eye end

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



8. Shear failure of fork end

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

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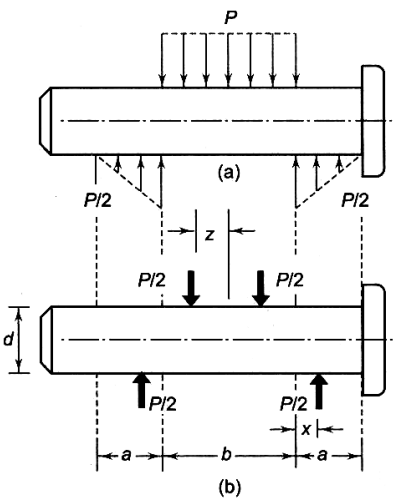
Knuckle Joint

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

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Knuckle Joint

Design of a Knuckle joint

9. Bending failure of pin

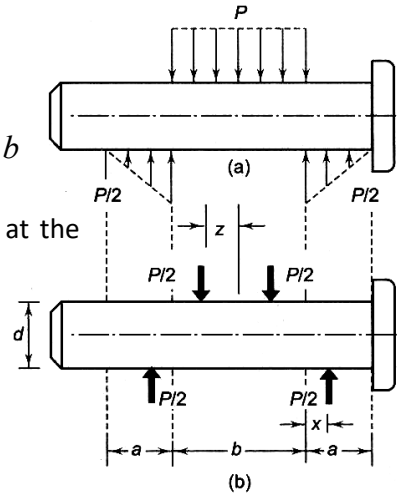
$$x = \frac{1}{3}a \quad \text{also} \quad z = \frac{1}{2}\left(\frac{1}{2}b\right) = \frac{1}{4}b$$

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

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Knuckle Joint

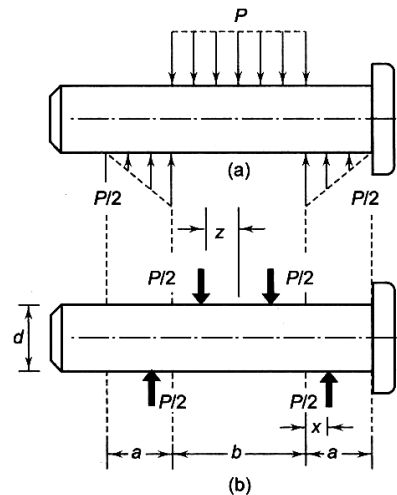
Design of a Knuckle joint

9. Bending failure of pin

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

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

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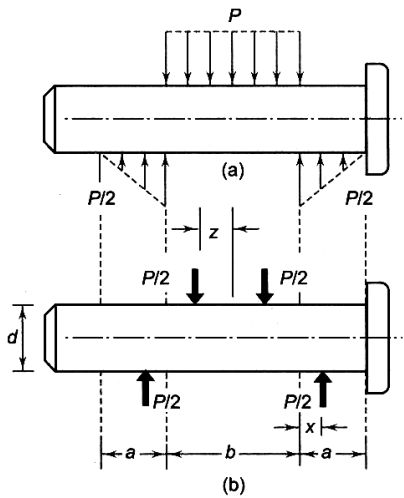
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9. Bending failure of pin

$$\sigma_b = \frac{32 P b a}{\pi d^3}$$
$$\sigma_b = \frac{16 P b a}{\pi d^3}$$



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 50 kN. All the components of the joint are to be made of steel.

References

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