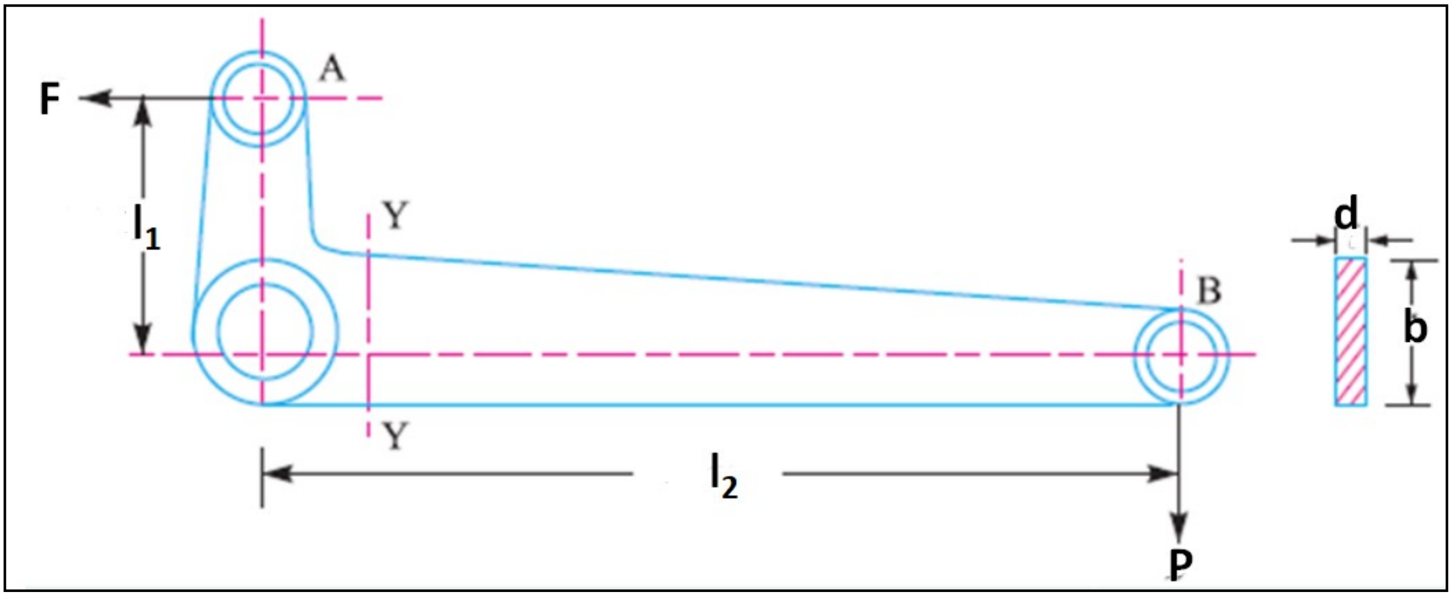
Standard size of Rod/Shaft/Tube/Bolts

Range of Size	Increment steps
0-10	1mm
10-24	2mm
24-45	3 mm
45-100	5 mm
>100	10 mm

Design of Bell Crank Lever

Design 7: Design a bell crank lever to carry a load of 35/40/50/55 KN at the end of a vertical arm. The mechanical advantage is 5 and the effort is to be applied in vertical direction at the end of a horizontal arm 800 mm in length. The allowable stresses in tension and shear for both lever and pin materials are 80 and 50 N/mm² respectively and allowable bearing pressure is 12 N/mm². Take a phosphorus bronze bush of 2.5 mm thickness.



Design Steps:

1. **Calculation of Load or Effort or their lengths:**

   Mechanical Advantage (M.A.) = $\frac{F}{P} = \frac{l_2}{l_1}$

   where, **P** = Small Effort to be applied (N)
   F = Load to be moved (N)
   l_1= length of load arm (mm)
   l_2= length of effort arm (mm)

   From the given information, find the effort P and length l_1.

2. **Lever Pin Design:**
   a) Resultant load on pin, $R = \sqrt{F^2 + P^2}$
   b) From bearing consideration of pin, $R = p_b l d$
   where, l is the length of pin
   And d is the diameter of pin
   Taking, $\frac{l}{d} = 1 - 2.5,$ solve and find l and standard d of the pin.
   c) Considering the double shear failure of pin

$$R = 2.\tau.\frac{\pi}{4}d^2$$

We find induced shear stress in pin as τ_i and check that it is < τ_{per} of pin material.

d) Bending stress in pin,

$$\sigma_b = \frac{M}{z} = \frac{Rl/6}{(\pi/32)d^3}$$

check that it is < σ_{per} of pin material. Else we increase diameter d of the pin

3. Checking the safety of boss:

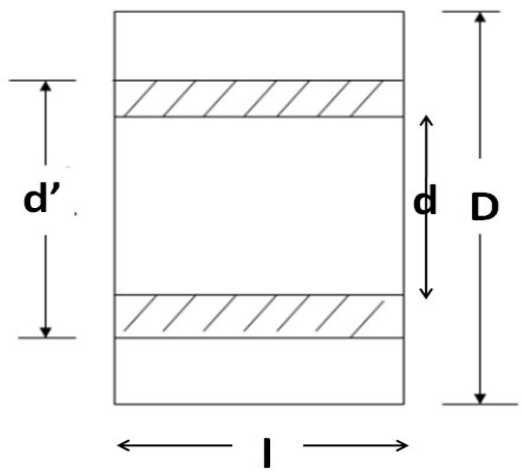
Considering a brass bush of thickness t mm

Diameter of bush, $d' = d + 2t$

Outer diameter of boss, $D = 2d$

Section Modulus of boss section,

$$z' = \frac{\frac{1}{12}l(D^3 - d^3)}{\frac{D}{2}}$$



Bending stress at boss,

$$\sigma_b = \frac{M}{z'} = \frac{Pl_2}{z'}$$

Check that above σ_b < σ_{per} of lever material.

Else we increase diameter D of the boss in steps of 2 mm until this condition is met.

4. Lever Pin Design:

Considering b/d = width to depth ratio of lever body as 1/4 to 1/3.

Considering section at length l' near fulcrum so that $l' = l_2 - (30 - 50mm)$

Bending stress at this section

$$\sigma_{b'} = \frac{M}{z''} = \frac{Pl'}{\frac{bd^2}{6}} = \sigma_{per}\ of\ lever\ material$$

Find b & d. and check that d< l, Else reiterate.

5. Effort Pin Design:

e) Load on effort pin in P N

f) From bearing consideration of pin, $P = p_b l_e d_e$

where, l_e is the length of effort pin

and d_e is the diameter of effort pin

Taking, $\frac{l_e}{d_e} = 1 - 2.5$, solve and find l_e and standard d_e of the pin.

g) Considering the double shear failure of pin

$$W = 2.\tau.\frac{\pi}{4}d_e^2$$

We find induced shear stress in effort pin as τ_i and check that it is < τ_{per} of pin material.

h) Bending stress in effort pin,

$$\sigma_b = \frac{M}{z} = \frac{Pl_e/6}{(\pi/32){d_e}^3}$$

check that it is < σ_{per} of effort pin material. Else we increase diameter d of the effort pin.

6. Load Pin Design:

Due to comparable loads we use the same load pin as the fulcrum pin.

VIVA QUESTIONS

1. Why are the arms of a bell crank lever made as tapered?
2. Why is the soft metal used in the eyes of the levers?
3. Which cross section is most suitable for lever body and why?
4. Why boss is generally needed at the fulcrum of the lever?