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Design of Lever Formulas

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List of 34 Design of Lever Formulas

Design of Lever

Components of Lever

1) Bending stress in lever of elliptical cross section

$$fx \quad \sigma_b = \frac{32 \cdot (P \cdot (l_1 - d_1))}{\pi \cdot b \cdot a^2}$$

[Open Calculator !\[\]\(de95854c7ee024cfadc48187bbb781b2_img.jpg\)](#)

$$ex \quad 239.6157N/mm^2 = \frac{32 \cdot (310N \cdot (900mm - 12.3913mm))}{\pi \cdot 14.3mm \cdot (28.6mm)^2}$$

2) Bending stress in lever of elliptical cross section given bending moment

$$fx \quad \sigma_b = \frac{32 \cdot M_b}{\pi \cdot b \cdot a^2}$$

[Open Calculator !\[\]\(6a9b39b98eb945faa14c645ec99e4eaa_img.jpg\)](#)

$$ex \quad 239.8293N/mm^2 = \frac{32 \cdot 275404N^*mm}{\pi \cdot 14.3mm \cdot (28.6mm)^2}$$



3) Bending stress in lever of rectangular cross section

$$fx \quad \sigma_b = \frac{32 \cdot (P \cdot (l_1 - d_1))}{\pi \cdot b_1 \cdot d^2}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235_img.jpg\)](#)

$$ex \quad 244.7137N/mm^2 = \frac{32 \cdot (310N \cdot (900mm - 12.3913mm))}{\pi \cdot 14.2mm \cdot (28.4mm)^2}$$

4) Bending stress in lever of rectangular cross section given bending moment

$$fx \quad \sigma_b = \frac{32 \cdot M_b}{\pi \cdot b_1 \cdot (d^2)}$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0_img.jpg\)](#)

$$ex \quad 244.9319N/mm^2 = \frac{32 \cdot 275404N*mm}{\pi \cdot 14.2mm \cdot ((28.4mm)^2)}$$


5) Effort Force Applied on Lever given Bending Moment

$$fx \quad P = \frac{M_b}{l_1 - d_1}$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f_img.jpg\)](#)

$$ex \quad 310.2764N = \frac{275404N*mm}{900mm - 12.3913mm}$$




6) Effort using Length and Load 

$$fx \quad P = l_2 \cdot \frac{W}{l_1}$$

Open Calculator 

$$ex \quad 310.8611N = 95mm \cdot \frac{2945N}{900mm}$$

7) Effort using Leverage 

$$fx \quad P = \frac{W}{MA}$$

Open Calculator 

$$ex \quad 310N = \frac{2945N}{9.5}$$

8) Leverage 

$$fx \quad MA = \frac{l_1}{l_2}$$

Open Calculator 

$$ex \quad 9.473684 = \frac{900mm}{95mm}$$

9) Load using Lengths and Effort 

$$fx \quad W = l_1 \cdot \frac{P}{l_2}$$

Open Calculator 

$$ex \quad 2936.842N = 900mm \cdot \frac{310N}{95mm}$$



10) Load using Leverage

$$fx \quad W = P \cdot MA$$

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a_img.jpg\)](#)

$$ex \quad 2945N = 310N \cdot 9.5$$

11) Maximum bending moment in lever

$$fx \quad M_b = P \cdot (l_1 - d_1)$$

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021_img.jpg\)](#)

$$ex \quad 275158.7N \cdot mm = 310N \cdot (900mm - 12.3913mm)$$

12) Mechanical Advantage

$$fx \quad MA = \frac{W}{P}$$

[Open Calculator !\[\]\(bd3b31712ad9bab5a241210fa6925cdd_img.jpg\)](#)

$$ex \quad 9.5 = \frac{2945N}{310N}$$

13) Reaction Force at Fulcrum of Lever given Bearing Pressure

$$fx \quad R_f = P_b \cdot d_1 \cdot l_f$$

[Open Calculator !\[\]\(7bc43b319a082987e20f7bf78f4bab80_img.jpg\)](#)

$$ex \quad 2963.999N = 20.8N/mm^2 \cdot 12.3913mm \cdot 11.5mm$$



14) Reaction Force at Fulcrum of Lever given Effort, Load and Contained Angle

$$fx \quad R_f = \sqrt{W^2 + P^2 - 2 \cdot W \cdot P \cdot \cos(\theta)}$$

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0_img.jpg\)](#)

$$ex \quad 2966.646N = \sqrt{(2945N)^2 + (310N)^2 - 2 \cdot 2945N \cdot 310N \cdot \cos(91^\circ)}$$

15) Reaction Force at Fulcrum of Right Angled Lever

$$fx \quad R_f = \sqrt{W^2 + P^2}$$

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5_img.jpg\)](#)

$$ex \quad 2961.271N = \sqrt{(2945N)^2 + (310N)^2}$$

Design of Fulcrum Pin

16) Bearing pressure in fulcrum pin of lever given reaction force and diameter of pin

$$fx \quad P_b = \frac{R_f}{d_1 \cdot l_f}$$

[Open Calculator !\[\]\(104fbf564e2e5a8fbd84f31656d114c7_img.jpg\)](#)

$$ex \quad 20.80001N/mm^2 = \frac{2964N}{12.3913mm \cdot 11.5mm}$$



17) Compressive stress in fulcrum pin of lever given reaction force, depth of lever arm

$$fx \quad \sigma_{t_{fp}} = \frac{R_f}{d_1 \cdot l}$$

[Open Calculator !\[\]\(9dfdaff1d86ba3c1f8353b4d1b61b8c5_img.jpg\)](#)

$$ex \quad 25.88184\text{N/mm}^2 = \frac{2964\text{N}}{12.3913\text{mm} \cdot 9.242006\text{mm}}$$

18) Diameter of fulcrum pin given compressive stress in pin

$$fx \quad d_1 = \frac{R_f}{\sigma_{t_{fp}} \cdot l}$$

[Open Calculator !\[\]\(2b376d1a92330ab09dad2665d2f89bf5_img.jpg\)](#)

$$ex \quad 12.38261\text{mm} = \frac{2964\text{N}}{25.9\text{N/mm}^2 \cdot 9.242006\text{mm}}$$

19) Diameter of fulcrum pin of lever given bending moment and effort force

$$fx \quad d_1 = (l_1) - \left(\frac{M_b}{P} \right)$$

[Open Calculator !\[\]\(c444627dab9fee9a1550c053ffaaaae2_img.jpg\)](#)

$$ex \quad 11.6\text{mm} = (900\text{mm}) - \left(\frac{275404\text{N*mm}}{310\text{N}} \right)$$



20) Diameter of fulcrum pin of lever given reaction force and bearing pressure

$$fx \quad d_1 = \frac{R_f}{P_b \cdot l_f}$$

[Open Calculator !\[\]\(6605b201d6f14d9b3bcb8ab5f274d107_img.jpg\)](#)

$$ex \quad 12.3913\text{mm} = \frac{2964\text{N}}{20.8\text{N}/\text{mm}^2 \cdot 11.5\text{mm}}$$

21) Length of flucrum pin of lever given reaction force and bearing pressure

$$fx \quad l_f = \frac{R_f}{P_b \cdot d_1}$$

[Open Calculator !\[\]\(e8fb589d58dad1692debababa5e928b6_img.jpg\)](#)

$$ex \quad 11.5\text{mm} = \frac{2964\text{N}}{20.8\text{N}/\text{mm}^2 \cdot 12.3913\text{mm}}$$

22) Length of fulcrum pin boss given compressive stress in pin

$$fx \quad l = \frac{R_f}{\sigma_{t_{fp}} \cdot d_1}$$

[Open Calculator !\[\]\(4688aadfd656ded00cd6bdfae55089a9_img.jpg\)](#)

$$ex \quad 9.235524\text{mm} = \frac{2964\text{N}}{25.9\text{N}/\text{mm}^2 \cdot 12.3913\text{mm}}$$

23) Maximum length of flucrum pin of lever given diameter of fulcrum pin

$$fx \quad l_f = 2 \cdot d_1$$

[Open Calculator !\[\]\(4146d17f71dced09c6ad789cacceaa6d_img.jpg\)](#)

$$ex \quad 24.7826\text{mm} = 2 \cdot 12.3913\text{mm}$$



Lever Arm

24) Angle between arms of lever given effort, load and net reaction at fulcrum

$$\text{fx } \theta = \arccos\left(\frac{W^2 + P^2 - (R_f')^2}{2 \cdot W \cdot P}\right)$$

[Open Calculator !\[\]\(d66ff64371a51729ac8c1cdaa685ba6f_img.jpg\)](#)

$$\text{ex } 90.99991^\circ = \arccos\left(\frac{(2945\text{N})^2 + (310\text{N})^2 - (2966.646\text{N})^2}{2 \cdot 2945\text{N} \cdot 310\text{N}}\right)$$

25) Depth of lever arm given width

$$\text{fx } d = 2 \cdot b_1$$

[Open Calculator !\[\]\(faf942dc3e59ce8eb64b4ac481eca7e0_img.jpg\)](#)

$$\text{ex } 28.4\text{mm} = 2 \cdot 14.2\text{mm}$$

26) Length of Effort Arm given Leverage

$$\text{fx } l_1 = l_2 \cdot MA$$

[Open Calculator !\[\]\(95b425611cbd2b8716a140cf67c81822_img.jpg\)](#)

$$\text{ex } 902.5\text{mm} = 95\text{mm} \cdot 9.5$$


27) Length of Effort Arm given Load and Effort

$$\text{fx } l_1 = W \cdot \frac{l_2}{P}$$

[Open Calculator !\[\]\(56549452e01ca28bdf2500ced9653143_img.jpg\)](#)

$$\text{ex } 902.5\text{mm} = 2945\text{N} \cdot \frac{95\text{mm}}{310\text{N}}$$



28) Length of effort arm of lever given bending moment 

$$fx \quad l_1 = (d_1) + \left(\frac{M_b}{P} \right)$$

[Open Calculator !\[\]\(0f848bbd71cef6b345273b16f905912a_img.jpg\)](#)

$$ex \quad 900.7913\text{mm} = (12.3913\text{mm}) + \left(\frac{275404\text{N}\cdot\text{mm}}{310\text{N}} \right)$$

29) Length of Load Arm given Leverage 

$$fx \quad l_2 = \frac{l_1}{MA}$$

[Open Calculator !\[\]\(3211b5d1d968fc1665909b34f9f16010_img.jpg\)](#)

$$ex \quad 94.73684\text{mm} = \frac{900\text{mm}}{9.5}$$

30) Length of Load Arm given Load and Effort 

$$fx \quad l_2 = P \cdot \frac{l_1}{W}$$

[Open Calculator !\[\]\(9c2e8d1b5bd77cb5c9f83b7a9cff79fd_img.jpg\)](#)

$$ex \quad 94.73684\text{mm} = 310\text{N} \cdot \frac{900\text{mm}}{2945\text{N}}$$

31) Length of major axis for elliptical cross sectioned lever given minor axis 

$$fx \quad a = 2 \cdot b$$

[Open Calculator !\[\]\(235bfe13ebf007ce2eea9e689707fac7_img.jpg\)](#)

$$ex \quad 28.6\text{mm} = 2 \cdot 14.3\text{mm}$$



32) Length of minor axis for elliptical cross sectioned lever given major axis

$$fx \quad b = \frac{a}{2}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235_img.jpg\)](#)

$$ex \quad 14.3mm = \frac{28.6mm}{2}$$

33) Outside diameter of boss in lever

$$fx \quad D_o = 2 \cdot d_1$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0_img.jpg\)](#)

$$ex \quad 24.7826mm = 2 \cdot 12.3913mm$$

34) Width of lever arm given depth

$$fx \quad b_1 = \frac{d}{2}$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f_img.jpg\)](#)

$$ex \quad 14.2mm = \frac{28.4mm}{2}$$









Variables Used

- **a** Major Axis of Lever Ellipse Section (*Millimeter*)
- **b** Minor Axis of Lever Ellipse Section (*Millimeter*)
- **b₁** Width of Lever Arm (*Millimeter*)
- **d** Depth of Lever Arm (*Millimeter*)
- **d₁** Diameter of Lever Fulcrum Pin (*Millimeter*)
- **D_o** Outside Diameter of Lever Boss (*Millimeter*)
- **l** Length of Pin Boss (*Millimeter*)
- **l₁** Length of Effort Arm (*Millimeter*)
- **l₂** Length of Load Arm (*Millimeter*)
- **l_f** Length of Lever Fulcrum Pin (*Millimeter*)
- **M_b** Bending Moment in Lever (*Newton Millimeter*)
- **MA** Mechanical Advantage of Lever
- **P** Effort on Lever (*Newton*)
- **P_b** Bearing Pressure in Fulcrum Pin of Lever (*Newton per Square Millimeter*)
- **R_f** Force at Lever Fulcrum Pin (*Newton*)
- **R_f'** Net Force at Lever Fulcrum Pin (*Newton*)
- **W** Load on lever (*Newton*)
- **θ** Angle Between Lever Arms (*Degree*)
- **σ_b** Bending Stress in Lever Arm (*Newton per Square Millimeter*)
- **σ_{t_{fp}}** Compressive Stress in Fulcrum Pin (*Newton per Square Millimeter*)










Constants, Functions, Measurements used

- **Constant:** **pi**, 3.14159265358979323846264338327950288
Archimedes' constant
- **Function:** **arccos**, arccos(Number)
Arccosine function, is the inverse function of the cosine function. It is the function that takes a ratio as an input and returns the angle whose cosine is equal to that ratio.
- **Function:** **cos**, cos(Angle)
Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.
- **Function:** **sqrt**, sqrt(Number)
A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- **Measurement:** **Length** in Millimeter (mm)
Length Unit Conversion 
- **Measurement:** **Pressure** in Newton per Square Millimeter (N/mm²)
Pressure Unit Conversion 
- **Measurement:** **Force** in Newton (N)
Force Unit Conversion 
- **Measurement:** **Angle** in Degree (°)
Angle Unit Conversion 
- **Measurement:** **Torque** in Newton Millimeter (N*mm)
Torque Unit Conversion 
- **Measurement:** **Stress** in Newton per Square Millimeter (N/mm²)
Stress Unit Conversion 



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