Important Design of Lever Formulas PDF

Formulas
Examples
with Units

List of 34
Important Design of Lever Formulas

1) Components of Lever Formulas

1.1) Bending stress in lever of elliptical cross section Formula

Evaluate Formula

Formula

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

Example with Units

$$239.6157\,\text{N/mm}^2 = \frac{32 \cdot \left(310\,\text{N} \cdot \left(900\,\text{mm} - 12.3913\,\text{mm} \right) \right)}{3.1416 \cdot 14.3\,\text{mm} \cdot 28.6\,\text{mm}^2}$$

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

Evaluate Formula

Formula

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

Example with Units

$$239.8293\,\text{N/mm}^2 = \frac{32 \cdot 275404\,\text{N*mm}}{3.1416 \cdot 14.3\,\text{mm} \cdot 28.6\,\text{mm}^2}$$

1.3) Bending stress in lever of rectangular cross section Formula

Evaluate Formula

Formula

$$\sigma_b = \frac{32 \cdot \left(P \cdot \left(l_1 - d_1 \right) \right)}{\pi \cdot b_l \cdot d^2}$$

Example with Units

$$244.7137\,\text{N/mm}^2 = \frac{32 \cdot \left(310\,\text{N} \cdot \left(900\,\text{mm} - 12.3913\,\text{mm} \right) \right)}{3.1416 \cdot 14.2\,\text{mm} \cdot 28.4\,\text{mm}^2}$$

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

Evaluate Formula

Formula

$$\sigma_b = \frac{32 \cdot M_b}{\pi \cdot b_l \cdot \left(d^2 \right)}$$

Example with Units

$$244.9319\,\text{N/mm}^2 = \frac{32 \cdot 275404\,\text{N*mm}}{3.1416 \cdot 14.2\,\text{mm} \cdot \left(28.4\,\text{mm}^2 \right)}$$

1.5) Effort Force Applied on Lever given Bending Moment Formula

Evaluate Formula

Formula

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

Example with Units

$$310.2764\,\text{N} = \frac{275404\,\text{N*mm}}{900\,\text{mm} - 12.3913\,\text{mm}}$$

1.6) Effort using Length and Load Formula

Evaluate Formula

Formula

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

Example with Units

$$310.8611\,\text{N} = 95\,\text{mm} \cdot \frac{2945\,\text{N}}{900\,\text{mm}}$$

1.7) Effort using Leverage Formula

Evaluate Formula

Formula

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

Example with Units

$$310\,\text{N} = \frac{2945\,\text{N}}{9.5}$$

1.8) Leverage Formula

Evaluate Formula

Formula

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

Example with Units

$$9.4737 = \frac{900\,\text{mm}}{95\,\text{mm}}$$

1.9) Load using Lengths and Effort Formula

Evaluate Formula

Formula

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

Example with Units

$$2936.8421\,\text{N} = 900\,\text{mm} \cdot \frac{310\,\text{N}}{95\,\text{mm}}$$

1.10) Load using Leverage Formula

Evaluate Formula

Formula

$$W = P \cdot MA$$

Example with Units

$$2945\,\text{N} = 310\,\text{N} \cdot 9.5$$

1.11) Maximum bending moment in lever Formula

Evaluate Formula

Formula

$$M_b = P \cdot \left(l_1 - d_1 \right)$$

Example with Units

$$275158.697\,\text{N*mm} = 310\,\text{N} \cdot \left(900\,\text{mm} - 12.3913\,\text{mm} \right)$$

1.12) Mechanical Advantage Formula

Evaluate Formula

Formula

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

Example with Units

$$9.5 = \frac{2945\,\text{N}}{310\,\text{N}}$$

1.13) Reaction Force at Fulcrum of Lever given Bearing Pressure Formula

Evaluate Formula

Formula

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

Example with Units

$$2963.999\,\text{N} = 20.8\,\text{N/mm}^2 \cdot 12.3913\,\text{mm} \cdot 11.5\,\text{mm}$$

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

Evaluate Formula

Formula

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

Example with Units

$$2966.6465\,\text{N} = \sqrt{2945\,\text{N}^2 + 310\,\text{N}^2 - 2 \cdot 2945\,\text{N} \cdot 310\,\text{N} \cdot \cos(91°)}$$

1.15) Reaction Force at Fulcrum of Right Angled Lever Formula

Evaluate Formula

Formula

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

Example with Units

$$2961.2708\,\text{N} = \sqrt{2945\,\text{N}^2 + 310\,\text{N}^2}$$

2) Design of Fulcrum Pin Formulas

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

Evaluate Formula

Formula

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

Example with Units

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

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

Evaluate Formula

Formula

$$\sigma t_{fp} = \frac{R_f}{d_1 \cdot l}$$

Example with Units

$$25.8818\,\text{N/mm}^2 = \frac{2964\,\text{N}}{12.3913\,\text{mm} \cdot 9.242006\,\text{mm}}$$

2.3) Diameter of fulcrum pin given compressive stress in pin Formula

Evaluate Formula

Formula

$$d_1 = \frac{R_f}{\sigma t_{fp} \cdot l}$$

Example with Units

$$12.3826\,\text{mm} = \frac{2964\,\text{N}}{25.9\,\text{N/mm}^2 \cdot 9.242006\,\text{mm}}$$

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

Evaluate Formula

Formula

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

Example with Units

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

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

Evaluate Formula

Formula

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

Example with Units

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

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

Evaluate Formula

Formula

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

Example with Units

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

2.7) Length of fulcrum pin boss given compressive stress in pin Formula

Evaluate Formula

Formula

$$l = \frac{R_f}{\sigma t_{fp} \cdot d_1}$$

Example with Units

$$9.2355\,\text{mm} = \frac{2964\,\text{N}}{25.9\,\text{N/mm}^2 \cdot 12.3913\,\text{mm}}$$

2.8) Maximum length of flucrum pin of lever given diameter of fulcrum pin Formula

Evaluate Formula

Formula

$$l_f = 2 \cdot d_1$$

Example with Units

$$24.7826\,\text{mm} = 2 \cdot 12.3913\,\text{mm}$$

3) Lever Arm Formulas

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

Evaluate Formula

Formula

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

Example with Units

$$90.9999° = \arccos\left(\frac{2945\,\text{N}^2 + 310\,\text{N}^2 - 2966.646\,\text{N}^2}{2 \cdot 2945\,\text{N} \cdot 310\,\text{N}}\right)$$

3.2) Depth of lever arm given width Formula

Evaluate Formula

Formula

$$d = 2 \cdot b_l$$

Example with Units

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

3.3) Length of Effort Arm given Leverage Formula

Evaluate Formula

Formula

$$l_1 = l_2 \cdot MA$$

Example with Units

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

3.4) Length of Effort Arm given Load and Effort Formula

Evaluate Formula

Formula

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

Example with Units

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

3.5) Length of effort arm of lever given bending moment Formula

Evaluate Formula

Formula

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

Example with Units

$$900.7913\,\text{mm} = \left(12.3913\,\text{mm}\right) + \left(\frac{275404\,\text{N*mm}}{310\,\text{N}}\right)$$

3.6) Length of Load Arm given Leverage Formula

Evaluate Formula

Formula

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

Example with Units

$$94.7368\,\text{mm} = \frac{900\,\text{mm}}{9.5}$$

3.7) Length of Load Arm given Load and Effort Formula

Evaluate Formula

Formula

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

Example with Units

$$94.7368\,\text{mm} = 310\,\text{N} \cdot \frac{900\,\text{mm}}{2945\,\text{N}}$$

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

Evaluate Formula

Formula

$$a = 2 \cdot b$$

Example with Units

$$28.6\,\text{mm} = 2 \cdot 14.3\,\text{mm}$$

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

Evaluate Formula

Formula

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

Example with Units

$$14.3\,\text{mm} = \frac{28.6\,\text{mm}}{2}$$

3.10) Outside diameter of boss in lever Formula

Evaluate Formula

Formula

$$D_o = 2 \cdot d_1$$

Example with Units

$$24.7826\,\text{mm} = 2 \cdot 12.3913\,\text{mm}$$

3.11) Width of lever arm given depth Formula

Evaluate Formula

Formula

$$b_l = \frac{d}{2}$$

Example with Units

$$14.2\,\text{mm} = \frac{28.4\,\text{mm}}{2}$$

Variables used in list of Design of Lever Formulas above

- **a** Major Axis of Lever Ellipse Section *(Millimeter)*
- **b** Minor Axis of Lever Ellipse Section *(Millimeter)*
- b_l Width of Lever Arm *(Millimeter)*
- **d** Depth of Lever Arm *(Millimeter)*
- d_1 Diameter of Lever Fulcrum Pin *(Millimeter)*
- D_o Outside Diameter of Lever Boss *(Millimeter)*
- **l** Length of Pin Boss *(Millimeter)*
- l_1 Length of Effort Arm *(Millimeter)*
- l_2 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)*
- σt_{fp} Compressive Stress in Fulcrum Pin *(Newton per Square Millimeter)*

Constants, Functions, Measurements used in list of Design of Lever Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- Functions: **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.*
- Functions: **cos**, cos(Angle) *Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.*
- Functions: **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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