МОДУЛЬ 1

1. Main definitions (machine, element, subassembly, two groups of machine elements).
2. Design and checking calculation Criteria of serviceability (characterize every criterion).
4. Determination of allowable stresses for plastic and brittle materials, variable loads.
5. Transmissions. Classification.
6. Parameters of mechanical drive
7. Gearings. Advantages of gearings. Classification of gearings
8. Failure of teeth (characterize every of them).
9. Materials and heat treatment of toothed wheels
10. Calculation of allowable contact and bending stresses
11. Geometry of standard spur gears. Forces in the engagement of spur gear
12. Helical gears features. Forces in the engagement. Equivalent straight spur gear
15. Forces in the engagement of the worm gearing. Material for worm gearing. Heat removal analysis of the worm gearing
Examples of problems

1. Determine centre distance \(a_w\), gear face width \(b_g\), pinion and gear nominal pitch circle diameters \(d^g\), \(d^p\), addendum circle diameters \(d_a^g\), \(d_a^p\), dedendum circle diameters \(d_f^g\), \(d_f^p\) of standard involute straight spur gear, if \(z^p=17\), \(z^g=51\), \(m=3\) mm, \(\psi_{ba}=0.4\).

2. Determine module \(m\), nominal pitch circle diameter \(d\), addendum circle diameter \(d_a\), dedendum circle diameter \(d_f\) and pitch \(P\) of the straight spur gear with external contact, if whole depth of a tooth \(h = 13.5\) mm, number of teeth \(z = 25\).

3. Determine normal module \(m_n\), helix angle \(\beta\), dedendum circle diameter \(d_f\), normal pitch \(P_n\), dedendum of a tooth \(h_f\) of the helical spur gear, if addendum circle diameter \(d_a=120\) mm, nominal pitch circle diameter \(d=112\) mm and number of teeth \(z = 27\).

4. Determine pitch angles \(\delta^p\), \(\delta^g\), outer cone distance \(R_e\), gear face width \(b_g\), external pitch circle diameter \(d_{ep}\), external addendum circle diameter \(d_{ap}\) of the pinion of bevel gears, if \(z^p=20\), \(z^g=63\), \(m_c=3\) mm, \(\psi_{br}=0.285\).

5. Determine external module \(m_e\), number of teeth of the gear \(z^g\), outer cone distance \(R_e\), external addendum circle diameter \(d_{ag}\), external dedendum circle diameter \(d_{fg}\) of the gear of bevel gears, if \(d_e^g= 135\) mm, \(h_f= 3.6\) mm, \(\delta^g=75^\circ\).

6. Determine centre distance \(a_w\) of the worm gearing, worm and worm gear pitch circle diameters \(d^w\), \(d^g\), major and minor diameters of the worm \(d_{aw}\) and \(d_{fw}\), lead angle \(\gamma\) of the worm, if \(z^w=1\), \(z^g=55\), \(q_w=8\), \(m=4\) mm.

7. Determine axial module \(m\), worm and worm gear pitch circle diameters \(d^w\), \(d^g\), addendum and dedendum circle diameters of the worm gear \(d_{ag}\) and \(d_{fg}\), lead angle \(\gamma\) of the worm, if \(a_w= 130\) mm, \(z^w=2\), \(z^g= 42\), \(q_w=10\).

8. Determine velocity ratio \(u\), efficiency \(\eta\), input and output torques \(T_{inp}, T_{out}\), input and output rotational speeds \(n_{inp}, n_{out}\) for single – stage speed reducer, if \(P_{inp}=4\) kW, \(P_{out}=3.5\) kW, \(\omega_{inp}=100\) sec\(^{-1}\), \(z^p=20\), \(z^g=60\).

9. Determine normal force \(F_n\), turning force \(F_t\) and radial force \(F_r\), acting at the engagement of straight spur gears, if torque at the pinion \(T^p=400\) N m, nominal pitch circle diameter of the pinion \(d^p=80\) mm, pressure angle \(\alpha_w=20^\circ\).

10. Determine normal force \(F_n\), turning force \(F_t\) and radial force \(F_a\) and axial force \(F_a\) acting at the engagement of helical spur gears, if torque at the pinion \(T^p=520\) N m, nominal pitch circle diameter of the pinion \(d^p=80\) mm, helix angle \(\beta=10^\circ\), pressure angle \(\alpha_w=20^\circ\).

11. Determine normal force \(F_n\), turning force \(F_t\), radial force \(F_r\) and axial force \(F_a\) acting on the pinion of bevel gears, if torque at the pinion \(T^p= 350\) N m, mean pitch circle diameter of the pinion \(d_{mp}= 100\) mm, pitch angle \(\delta^p=16^\circ\), pressure angle \(\alpha_w=20^\circ\).

12. Determine normal force \(F_n\), turning force \(F_t\), radial force \(F_r\) and axial force \(F_a\) acting at the engagement of the worm gearing, if torque at the worm \(T^w=120\) N m, torque at the worm gear \(T^g= 1350\) Nm, major diameter of the worm \(d^w=80\) mm, pitch circle diameter of the worm gear \(d^g= 250\) mm, lead angle \(\gamma=13^\circ\), pressure angle \(\alpha_w=20^\circ\).
МОДУЛЬ 2

2. Determination of the shaft minimal diameter. Designing the shaft construction.
3. Bearings (sliding contact bearings and rolling contact bearings). Advantages (disadvantages) of rolling contact bearings.
4. Classification of rolling contact bearings. Main failures. Calculation of rolling contact bearings
8. Threaded joints. Advantages and disadvantages. Characterise threaded joints formed by a bolt, a screw and a stud
**Examples of problems**

1. Determine the minimal diameter and design the shaft of the single stage bevel gear speed reducer if $T = 300 \text{ N m}$, $[\tau] = 20 \text{ MPa}$.

2. Determine rated life in hours $L_h$ for tapered roller bearing with movable inner ring, if $F_r = 15 \text{ kN}$, $F_a = 5 \text{ kN}$, $X = 0.6$, $Y = 1.8$, $C = 40 \text{ kN}$, $n = 120 \text{ rpm}$, $t < 100 \degree \text{C}$, $K_s = 1.3$.

3. Determine basic load rating $C$ for radial-thrust ball bearing with movable inner ring, if $F_r = 16 \text{ kN}$, $F_a = 2 \text{ kN}$, $X = 0.45$, $Y = 1.62$, $L_h = 12000 \text{ hours}$, $n = 80 \text{ rpm}$, $t < 100 \degree \text{C}$, $K_s = 1.3$.

4. Select a sunk key for the shaft of diameter $d = 40 \text{ mm}$ and analyse it for bearing strength and shearing strength, if torque $T = 250 \text{ N m}$, design key length $l_d = 56 \text{ mm}$, $[\sigma_{\text{bear}}] = 100 \text{ MPa}$, $[\tau_{\text{shear}}] = 60 \text{ MPa}$.

5. Determine bolt diameter $d$ of the tightened threaded joint loaded by a torque only, if $F_{\text{ten}} = 8 \text{ kN}$, $[\sigma_{\text{ten}}] = 100 \text{ MPa}$.

6. Determine bolt diameter $d$ of the threaded joint loaded by an axial force $F_a$ only, if $F = 7 \text{ kN}$, $[\sigma_{\text{ten}}] = 100 \text{ MPa}$.

7. Determine bolt diameter $d$ of the threaded joint when bolt is fitted into hole with some play, if $F = 2 \text{ kN}$ (not $F_{\text{pr}}$), $[\sigma_{\text{ten}}] = 130 \text{ MPa}$, $f = 0.2$, $i = 2$.

8. Determine bolt diameter $d_0$ of the threaded joint when bolt is fitted into hole with small interference, if $F = 8 \text{ kN}$, $[\tau] = 60 \text{ MPa}$.

9. Determine the number of required rivets if the rivet diameter $d = 4 \text{ mm}$, shearing force $F = 17 \text{ kN}$, the minimum thickness of the plate $\delta = 3 \text{ mm}$ and the allowable shearing stress $[\tau] = 270 \text{ MPa}$.

10. Determine the bearing force $F$ of riveted joint if the rivet diameter $d = 4 \text{ mm}$, number of rivets $z = 4$, the minimum thickness of the plate $\delta_{\text{min}} = 10 \text{ mm}$ and the allowable bearing stress $[\sigma] = 250 \text{ MPa}$.

11. Determine the plate width $(b)$ if the rivet diameter $d = 6 \text{ mm}$, $z = 2$, the minimum thickness of the plate $\delta_{\text{min}} = 7 \text{ mm}$, tearing force $F = 28 \text{ kN}$, and the allowable tensile stress $[\sigma] = 400 \text{ MPa}$.

12. Check lap weld for shear if the shearing force $F = 12 \text{ kN}$, length weld $l = 40 \text{ mm}$, thickness of the plate $\delta \text{ (k)} = 7.5 \text{ mm}$. Allowable shear stress $[\tau]' = 100 \text{ MPa}$.

13. Determine the tearing force of the butt weld, if thickness $\delta = 6 \text{ mm}$, width $b = 70 \text{ mm}$. The allowable tensile stress $[\sigma]' = 110 \text{ MPa}$.