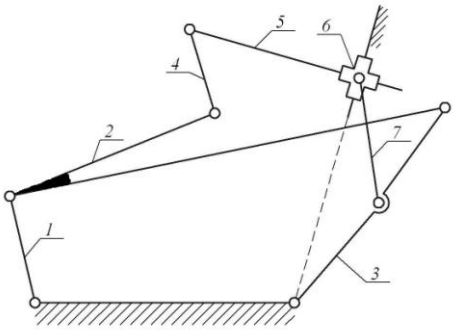
Theory of Machines and Mechanisms

Olympiad for
Students of Russian Technical Universities
2008

Problems

TMM – 1 **Mark: 2 points**



1. Determine the number of degrees of freedom (DOF) *W* of the mechanism shown.
2. Dismember the mechanism into *Assur* kinematic chains, using all initial links. Make classification of found kinematic chains.
3. Set up structural formulas of the mechanism. Determine class of the mechanism.

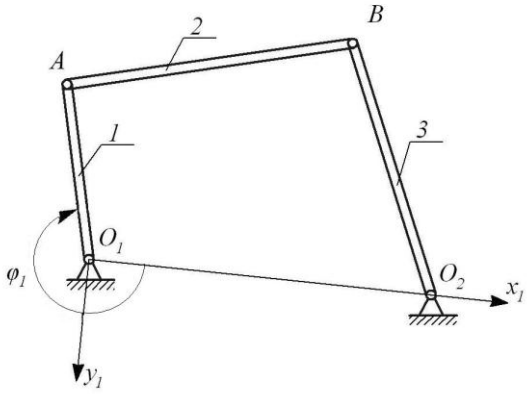
TMM – 2 **Mark: 4 points**

Make kinematic synthesis of four-bar linkage on the base of three given positions of crank OA (link1) and three corresponding positions of rocker CD (link 3).

$A_1D_1 \neq A_2D_2 \neq A_3D_3$

Use *Fig.1* (*Appendix 1*) for graphical solution.

TMM – 3 **Mark: 5points**



Given: kinematic scheme of mechanism;

l_{O_1A} – length of crank; l_{AB} – length of connecting link;

l_{O_2B} – length of rocker; $l_{O_1O_2}$ – distance between fixed hinges.

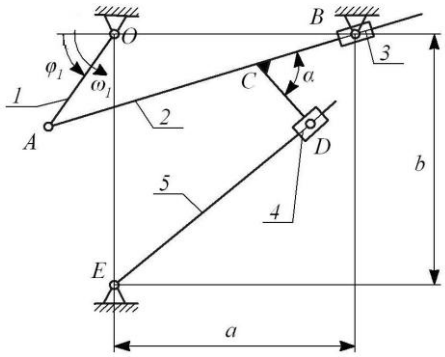
Determine analytically:

1) angular velocity ratio for rocker *3*: $\omega_{q3} = \frac{\omega_3}{\omega_1}$;

2) angular velocity ratio for connecting link *2*: $\omega_{q2} = \frac{\omega_2}{\omega_1}$;

What condition should be satisfied in order ω_{q3} takes maximum value?

TMM – 4 **Mark: 5 points**



Given:

$l_{OA} = 0{,}3$ m; $l_{AC} = 0{,}4$ m; $l_{CD} = 0{,}35$ m; $\alpha = 40^\circ$;

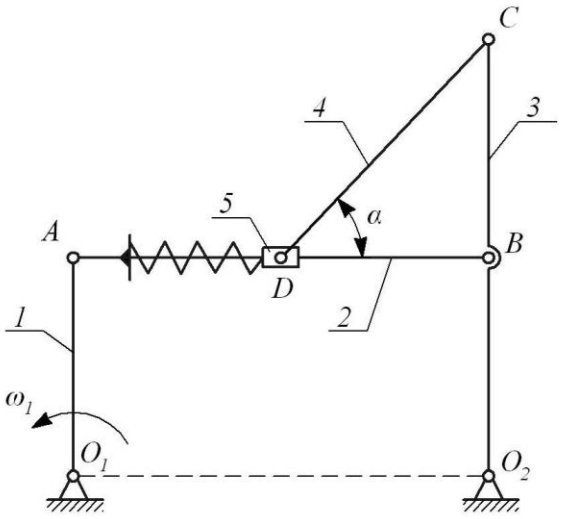
$a = 0.5$ m; $b = 0{,}9$ m; $\omega_1 = 7\ \frac{1}{\text{s}}$; $\varphi_1 = 45^\circ$.

Determine velocity and acceleration of point *D* which belongs to link *5*.

Fig. 2 (*Appendix 2*) shows the kinematic scheme of the mechanism.

This problem worth 3 points if being solved in a general form (without calculations).

TMM – 5 **Mark: 6 points**



Given:

$\omega_1 = 10\ \frac{1}{\text{s}}$; $\alpha = 45^\circ$;

$l_{O_1A} = l_{O_2B} = l_{BC} = 0{,}1$ m.

Mass of link *5* is $m = 10$ kg. Center of gravity of link 5 is located at point D. All the rest links are assumed weightless.

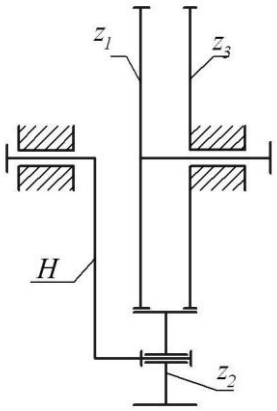
At the position shown compressed spring exerts the force of $F_{el} = 100$ N.

Determine:

1. Torque M_1 to be applied to crank shaft 1 in order to provide zero angular acceleration of the crank shaft $(\varepsilon_1 = 0)$ at the shown position.
2. Constraint forces acting at revolute pair C and prismatic pair D (provided that $\varepsilon_1 = 0$).

Assume g = 10 m/s^2 for the acceleration due to gravity.

TMM – 6 **Mark: 5 points**



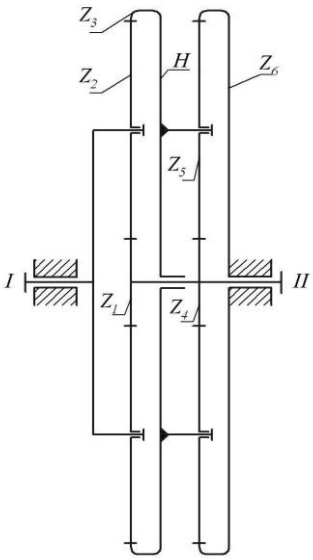
Given:

Gear ratio $U^3_{H-1} = 40$; $z_1 = 40$; $z_2 = 12$. Dimensionless shift coefficient of cutting rack for wheel z_1 (shift of cutting rack divided by module) is x_1=0.2. Angular speed of bracket *H* is $\omega_H = 10\ \frac{1}{s}$. All links have equal mass of 0.1 kg. All wheels have the module of $m = 1$ mm.

Determine:

1. Shift coefficient of cutting rack for wheel z_3 in order to provide zero backlash. Gear wheel z_2 has no undercut.
2. Inertia force acting on satellite bearings.

TMM – 7 **Mark: 7 points**



Given:

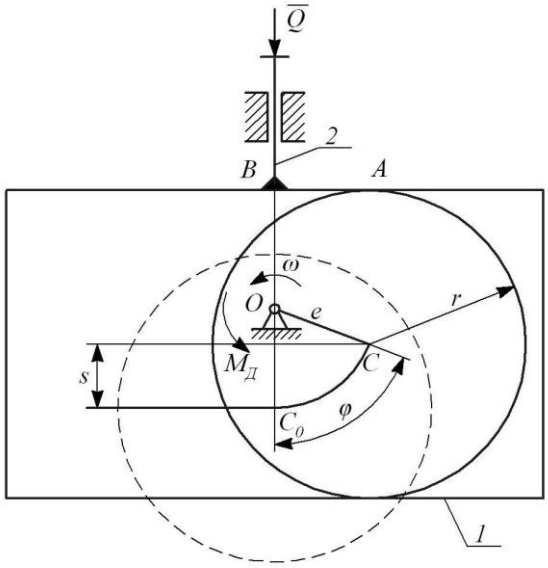
Number of teeth $z_1 = 16;\quad z_2 = 40; z_4 = 14;\quad z_5 = 43.$

H denotes bracket, *I* and *II* – input and output shafts, respectively.

Determine ratios:

$$\frac{\omega_H}{\omega_I};\quad \frac{\omega_{II}}{\omega_I}.$$

TMM – 8 **Mark: 6 points**



Given:

r = 0,030 m; e = 0,015 m.

Both driving torque M_d and resistance force Q are assumed constant while the system is in steady-state (normal) operation. Force Q = 1200 N acts only during rise of follower.

Coefficient of Coulomb friction within the pair «cam-follower» is f = 0.1.

Any force of resistance except for Q, as well as weights, is to be neglected.

Reduced moment of inertia of the aggregate takes constant value of $I = 4\ \text{kg} \cdot \text{m}^2$.

Determine:

1. Total resulting moment of resistance and friction $M_C = M_Q + M_F$ reduced to cam shaft, as a function of angle φ . Calculate M_C for φ = 0, and φ =π.
2. Value of reduced driving torque M_d.

NOTE: No equivalent mechanism can be used to find $v_{A_1A_2}$.

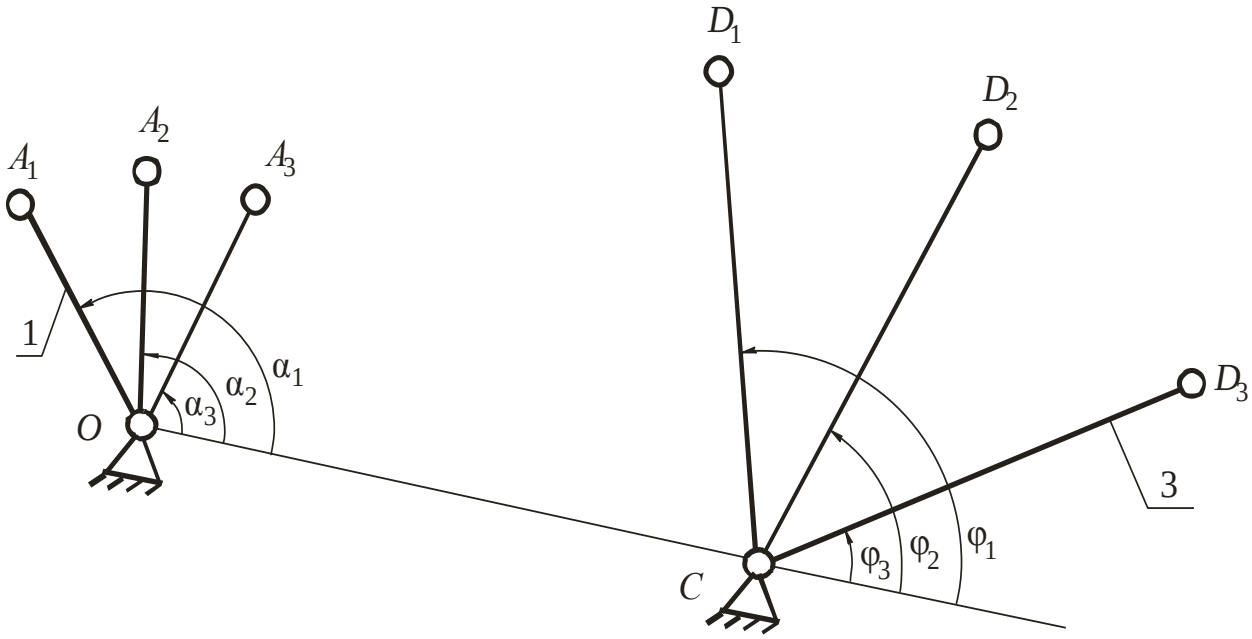

D_1
D_2
D_3
A_1
A_2
A_3
1
3
O
C
α_1
α_2
α_3
φ_1
φ_2
φ_3

Fig. 1

$$K_l = \frac{0{,}30}{60} = \quad 0{,}005 \frac{\text{м}}{\text{мм}}$$

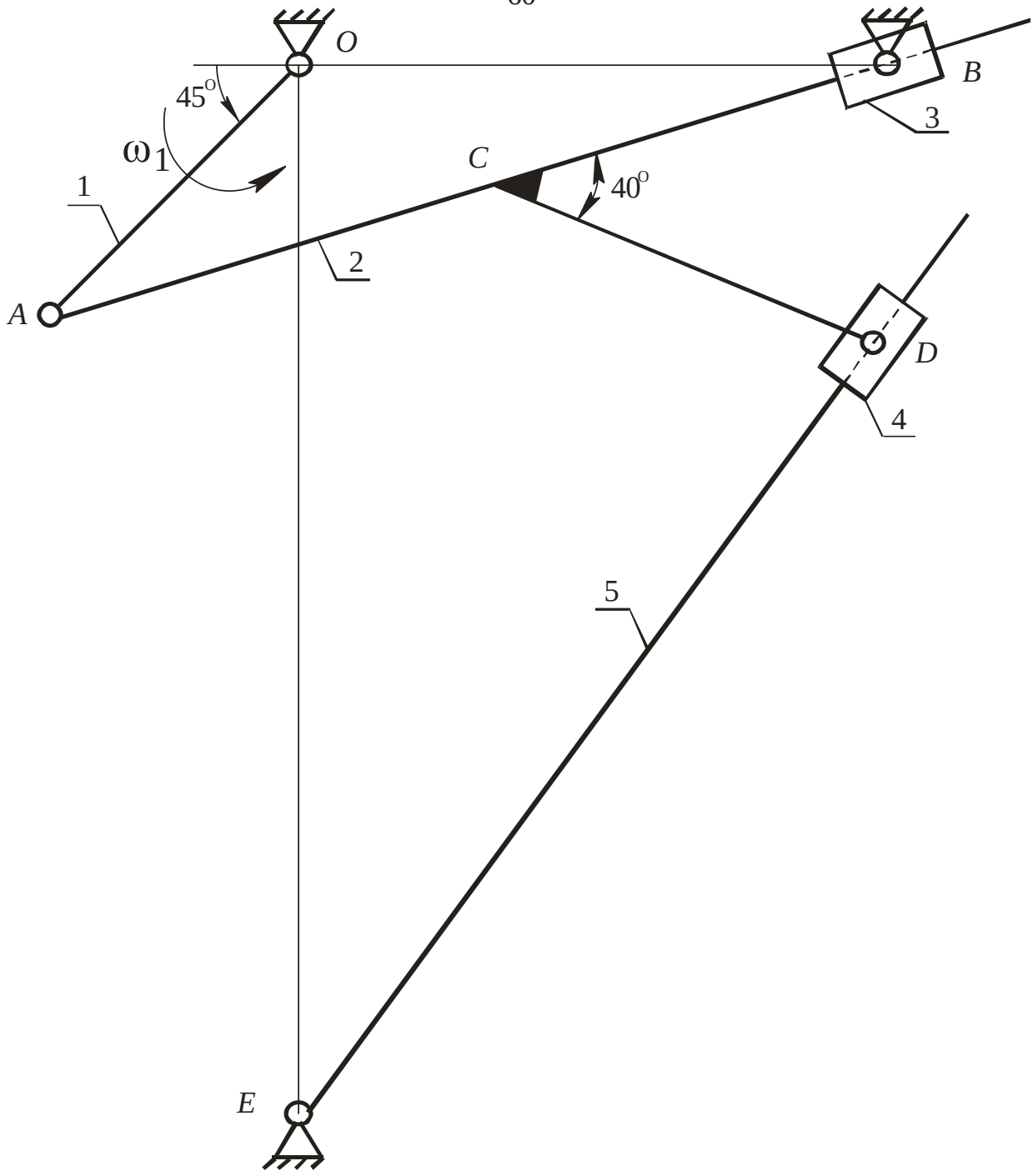


Fig. 2