# 436-431 MECHANICS 4 UNIT 2
# DYNAMICS

NAME 1..........................................................................ID.............................................
NAME 2 .........................................................................ID.............................................

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# ASSIGNMENT

## ANALYSIS OF VIBRATIONS OF A VENTILATOR

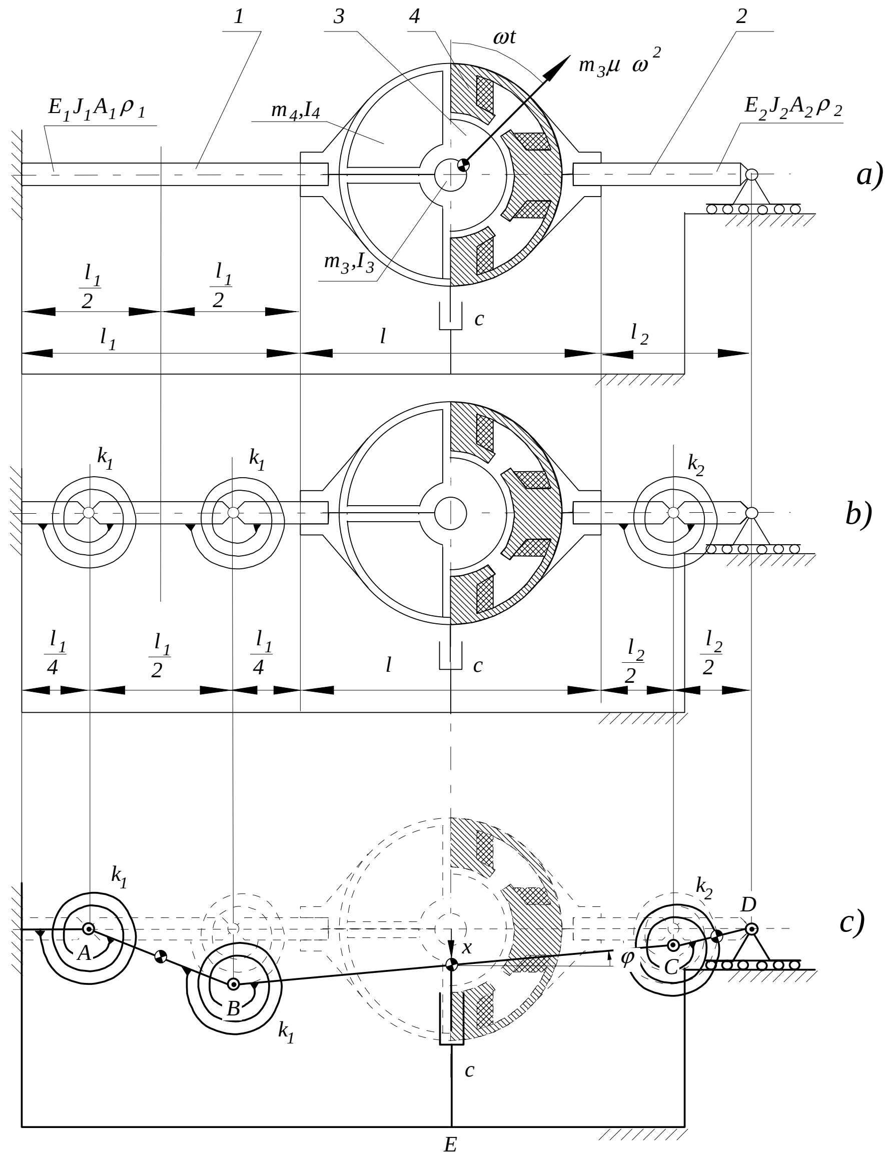


Fig. 1

The electric motor *3-4* shown in Fig. 1a is supported by two elastic beams *1* and *2*. Parameters of this assembly are as follows
$m_3 = 20kg$ - mass of the rotor *3* of the electric motor
$I_3 = 0.05kgm^2$ - moment of inertia of the rotor about its axis of rotation
$\mu = 0.00001m$ - the static unbalance of the rotor
$\omega = 3000RPM$ - the angular velocity of the rotor
$m_4 = 35kg$ - mass of the stator *4* of the electrical motor
$I_4 = 1.8kgm^2$ - moment of inertia of the stator *4* about asis of rotation of the rotor *3*
$l = 0.6m$ - width of the electric motor
$l_1 = 2m$ - length of the beam *1*
$l_2 = 1m$ - length of the beam *2*
$J_1 = 1 \times 10^{-6}m^4$ - the second moment of area of the cross-section of the beam *1*
$J_2 = 1 \times 10^{-6}m^4$ - the second moment of area of the cross-section of the beam *2*
$A_1 = 0.0008m^2$ - area of the cross-section of the beam *1*
$A_2 = 0.0008m^2$ - are of the cross-section of the beam *2*
$E_1 = E_2 = 2 \cdot 10^{11}N/m^2$ - Young modulus of the material the beams *1* and *2* are made of
$\rho_1 = \rho_2 = 7800kg/m^3$ - density of the material the beams are made of
$c = 1000Ns/m$ - the coefficient of damping of the damper

To create the mathematical model for analysis of vibrations of this system, the beam *1* was divided into to sections each of length $l_1/2$. The bending properties of each section, according to the Rigid Element Method, can be approximated by a hinge and the spring of stiffness $k_1$ calculated from the following formula.

$$k_i = \frac{E_i J_i}{l_i}$$

where $E_i$ stands for the Young modulus, $J_i$ stands for the second moment of area and $l_i$ stands for the length of the $i-th$ segment.

Similarily the bending properties of the beam *2* were approximated by a hinge and the spring of stiffness $k_2$ as shown in Fig 1b. The elements between the hinges now can be considered rigid and thin rods. This physical model has two degree of freedom. Therefore the two coordinates $x$ and $\varphi$ shown in Fig. 1c determine position of the system. For this physical model produce

1. the differential equations of small vibrations of the system by means of the Lagrange's approach
2. the differential equations of small vibrations of the system by means of the Newton's approach
3. coordinates $x$ and $\varphi$ corresponding to the equilibrium position of the system.
4. the natural modes and the natural frequencies of the undamped vibrations
5. draw the natural modes
6. the natural frequencies of the damped vibrations
7. amplitude of the forced vibrations due to the unbalance of the rotor $\mu$ for the working speed $\omega = 3000RPM$
8. resonance diagram in range of the excitation frequency $0 < \omega < 1000rad/s$
9. The reaction produced by the damper at the point $E$ for the working speed $\omega = 3000RPM$

Students are allowed to work on this assignment individualy or in groups of two