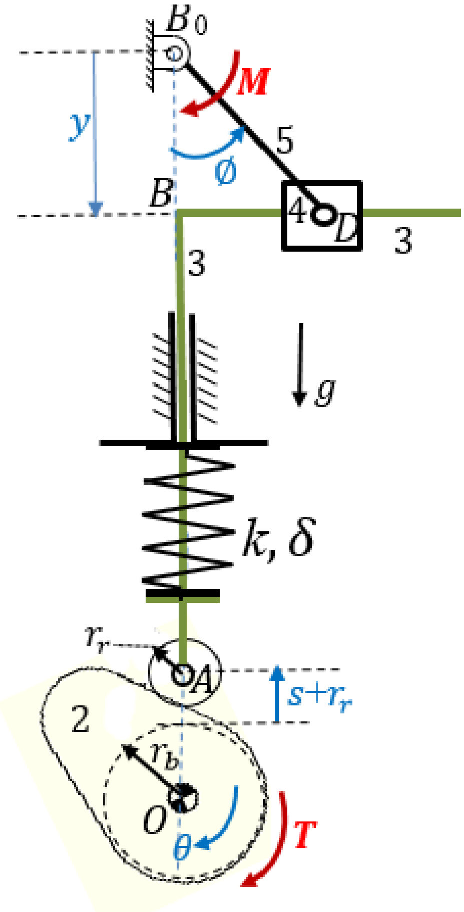
ME 418 – Dynamics of Machinery
2021-2022 Spring PROJECT-2

Due Date:16:06:2022 23:59 (10% reduction for each hour of late submission)



Project Description

A force closed disk cam causes in-line translating roller follower to rise $H = 0.06\,m$ by simple harmonic motion for $0° \leq \theta \leq 150°$ followed by simple harmonic return for $150° \leq \theta \leq 360°$, where θ is the cam shaft angle, and $\theta = 0^0$ at the beginning of rise (when $s = 0$).
The roller radius is $r_r = 12$ mm. Base circle radius is $r_b = 40$ mm. The spring constant is $k = 20000$ N/m, and it is pre-compressed by $\delta = 10$ mm, when $s = 0$.

Link-2 (cam) and link-5 are balanced and their mass centres coincide with respective fixed rotation axes. Their mass moment of inertia are: $I_{O_2} = 0.02\ \text{kgm}^2$ and $I_{B_{0_5}} = 0.05\ \text{kgm}^2$. The crank length $|B_0D| = a_2 = 0.18$ m. Distance between two fixed pivots is $|OB_0| = a_1 = 0.3$ m.

Link-3 (follower) has a mass of $m_3 = 7$ kg, and $|AB| = a_3 = 0.1$ m.

Roller and link-4 have negligible mass.

A constant clock-wise external working moment $M = 150$ Nm is applied on link-5 during the rise period of follower motion. Ignore friction. Gravity acts downward.

The mechanism is expected to operate at an average speed of $400rpm$ revolutions per minute.

What you are required to do?

Basically, you are required to simulate the dynamic motion of the mechanism described above and design a suitable drive system consisting of an AC induction motor, a gearbox, and, if necessary, a flywheel.

Note that, along with the motor inertia, you also need to include the rotary inertia of the gearbox in your simulation, both reduced to the cam-shaft.

You may approximate the gear-box inertia reduced to the motor shaft as $(1 + 0.1r) \times (Motor\ Inertia)$, where $r > 1$ is reduction ratio.

Details of what you are required to do and sumit are as follows:

a) Write down all equations for dynamic modelling. (i.e. everything you need for the code and steps below, except step f)

b) Check if the cam parameters specified above are approriate in terms of pressure angle and undercutting.

c) Plot variation of **generalized inertia without motor or gearbox** versus the generalized coordinate θ.

d) Plot variation of **centripetal inertia without motor or gearbox** versus the generalized coordinate θ.

e) Plot variation of generalized force versus the generalized coordinate θ due to external moment M, due to weights and due to spring force, separately.

f) Develop a dynamic motion simulation code.

g) Design a suitable drive system consisting of an electric motor chosen from the EMTAŞ catalog and a gearbox using the model by E. Söylemez.

   Your design is required to satisfy the following five criteria:

   i. **Initial Cost:** Although exceptions may naturally exist, it is reasonable to assume that smaller weight and rated power of the motor and smaller flywheel size result in less initial cost. Determine *Initial Cost Measure* of your final design by indicating rated power (in kW) and weight (in kg) of the motor chosen and flywheel size (in kgm^2) if employed.

   ii. **Stability:** To ensure a safe steady-state operation away from the unstable region, minimum motor speed must be sufficiently higher than the breakdown speed. Determine the *Stability Measure* of your final design as the ratio: $(\omega_{min} - \omega_b)\ /\ (\omega_s - \omega_b)$.

   iii. **Speed Fluctuation:** Speed fluctuation is required to be sufficiently small for a steady operation. Determine a *Speed Fluctuation Measure* of your final design by indicating the resulting coefficient of speed fluctuation.

   iv. **Running Cost:** At steady-state, motor speed is required to vary between ω_{max} and ω_{min} in the close vicinity of the point of maximum efficiency. Determine the *Running Cost Measure* of your final design by calculating the ratio: $\left|\omega_{average} - \omega_{nominal}\right| / (\omega_s - \omega_b)$.

   v. **Service Life:** Among several other factors, fast start-up transient results in less heating and consequently longer service life. Determine *Service Life Measure* of your final design as the time it takes for the cam-shaft to reach its steady state average speed ($\omega_{average}$) for the first time from start-up.

In this part, you are expected to give an account of iterations performed until you reach the final solution, and discuss assumptions and choices you have made (if any).

h) Plot the following for your final solution:
   i. Torque-speed characteristics of the motor chosen
   ii. Motor torque reduced to the cam-shaft versus its speed
   iii. Cam-shaft speed versus time

i) Using your final solution, check if follower jump occurs. Clearly present the procedure (explanations, FBD's, equations, etc.).

j) Provide a table for your drive selection in the following format at the beginning of the first page of your report.

Motor Chosen: NM- ; Reduction Ratio of Gear Box:			
Initial Cost Measure	Power	Weight	Flywheel Size
Stability Measure			
Speed Fluctuation Measure			
Running Cost Measure			
Service Life Measure			

You are required to include a printout of the code used in the solution package you will submit, and also submit the code to the Project-2 code submission area on ODTUClass. If you do not attach your software code to your submission, and/or do not submit your code to the Project-2 code submission area on ODTUClass, the corresponding part(s) will not be graded.

You are expected to provide:

- ✓ *clear explanation of each step of your solution,*
- ✓ *proper units,*
- ✓ *well annotated, scaled plots (title, axis labels, units, legend), not random hand sketches*

Your report should have a cover page and index as well. The topics in the index may be similar to the example below:

1) Introduction
2) Dynamic modeling and Design of the Drive
   a) Part a

b) Part b
c) Part c
d) Part d
e) Part e
f) Part f
g) Part g
h) Part h
i) Part i

3) Concluding Remarks