Mechatronics MSc State Exam Topics (Cyber Physical Systems)

CYBER SECURITY

1. CS1: What is Cyberspace (defining, important IT functionality must be protected, Offensive cyber operations can also have non-defensive purposes, SSH Encryption….)
2. CS2: Strategy to Secure Cyberspace (what are critical infrastructures, what is the threat, Critical Priorities for Cyberspace Security……)
3. CS3: Industrial Control Systems (ICS) security (Smart grid, The Data-Driven Economy….)

SOFTWARE IN THE LOOP AND HARDWARE IN THE LOOP

4. HIL1: Software In the Loop (SIL, 'V' model,) Hardware in the loop (HIL-simulation, Real-time simulation
5. HIL2: The integration of SIL and HIL V model, Theoretical automation pyramid, Practical automation pyramid
6. HIL3: Theoretical automation pyramid, Practical automation pyramid OSI

COMPONENT OF CYBER PHYSICAL SYSTEMS

7. CP1: Interplay between CS, ICT and manufacturing automation, automation hierarchy with distributed services
8. CP2: Characteristics Of Industry 4.0 And Industrial Solutions, Comparison of the present factory and Industry 4.0 factory
9. CP3: Cyber Physical Factory – Cyber Physics Reality, Internet of things, Processes In The Internet Of Things
10. CP4: Revolutions" of the industry, Cyber Physical Factory – Cyber Physics Reality, Idea And Prototype
11. CP5: Practical thinks for implementing digital projects (implementing Industry 4.0, application scenarios
12. CP6: Industrial automation and control systems – IACS, Reference models

MODELLING ROBOTS

13. MR1: Denavit Hartenberg Parameters What are the main differences between an open kinematic chain, and closed kinematic chain robot mechanism?
14. MR2: Which parameters must be paid attention to during 3D modelling of a robotic arm?
15. MR3: What does the „degrees of freedom" (DoF) of a robot mean? What's the connection between the amount of degrees of freedom of a robot, and its ability to complete tasks?

16. MR4: Robots with kinematic redundancy (Typical cases of redundant robots, disadvantages of redundancy, inverse kinematics problem, Jacobian-based methods, null-space methods, task augmentation methods, Singularity robustness

SPATIAL MECHANISMS AND DYNAMICAL SYSTEMS

SM1: 1/ Theory

Please describe the Lagrangian methods for linear dynamical systems, the Lagrangian equations. Please compare the Lagrangian methods to the Newton-Euler method. What does the transfer function means in dynamical systems? Please show the transfer functions of the mass-damper-spring system considering its elements seperatly.

SM2: 2/ Theory

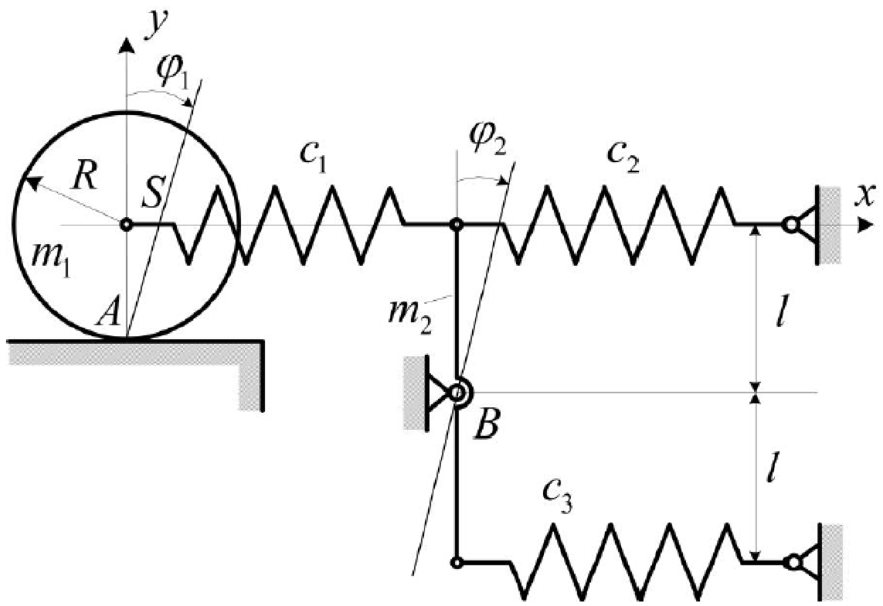
Please describe the main groups of the mechanisms and kinematic pairs/ joints. Describe the velocity diagram of the cam follower mechanism. Please describe the pantograph and the Klann mechanisms and their application areas in engineering.

SM3: 1/ Exercise:

Higher DOF linear dynamical system is given with its mechanical model. Describe the system with second order Lagrangian equation with detailed parametric calculation!

- Please calculate the value of the mass matrice!
- Please calculate the value of the stiffness matrice!

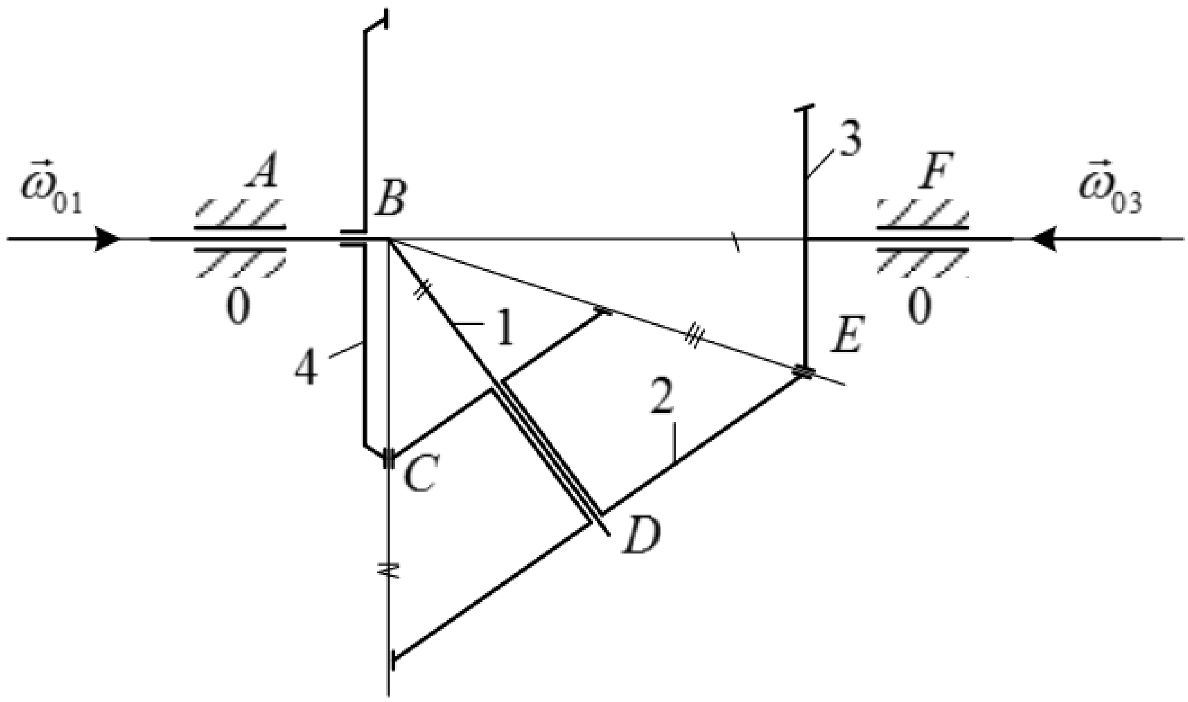
m_1=30 kg **m_2=60 kg** **$c_1=c_2=4*10^{-4}$ m/N** **l=1 m** **R=0.5 m**



SM4: 2/ Exercise:

Spatial bevel gear mechanism is given with its mechanical model with ω_{01} and ω_{03} angular velocity inputs.

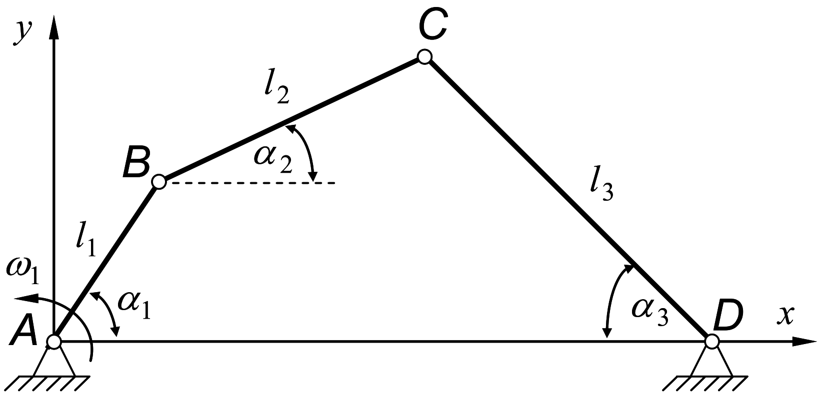
- Please construct the angular velocity diagram.
- Please determine the ratio of i_{14} parametric.



SM5: 3/ Exercise:

For-bar linkage mechanism is given with their length of thge AB, BC CD rods and degrees. Furthermore the angular speed of the AB rod is known.

$l_1 = 5m,\ l_2 = 7m,\ l_3 = 6\sqrt{2}m,\ \alpha_1 = 60^\circ,\ \alpha_2 = 30^\circ$ $\alpha_3 \Rightarrow$ therefore , $\omega_1 = 5\frac{1}{s}$.



- Please calculate the velocity of the B and C points.
- Please calculate the angular velocity of the 2nd and 3rd rods.
- Please determine the degree of freedom (DOF) of the mechanism.

Electrotechnics

1. ET1: Draw the transistors electrical symbol, in-output characteristics, write the transistor equations, and explain the nomenclatures!

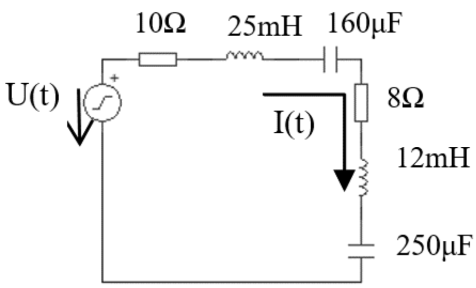
2. ET2: Draw the MOSFET's and JFET's electrical symbols, in-output characteristics, write the equations, and explain the nomenclatures.

3. ET3: Explain the types of power amplifiers.

4. ET4: Explain the types of operation amplifiers.

5. ET5: Exercise: Calculate the circuit's Active, Reactive and Complex Power and the Power Factor. Draw the Voltage and Current time functions in coordination system.

   U(t)=17 sin(314t+22°)V



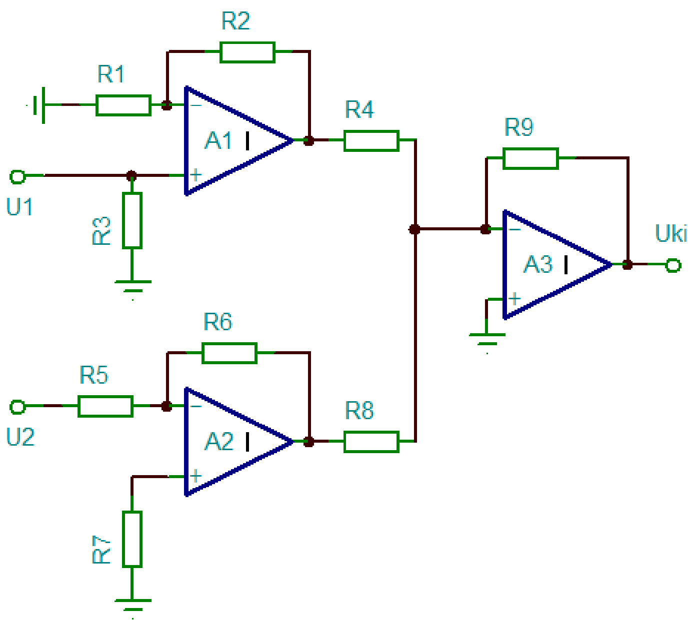
6. ET6: What types of basic circuits in Figure and how much the circuit total gain value?

R_1=100Ω, R_2=10kΩ, R_3=100Ω, R_4=200Ω, R_5=1kΩ, R_6=50kΩ, R_7=1kΩ, R_8=200Ω, R_9=15kΩ, U_1=U_2

A_1……………….type Op Amp

A_2………………. type Op Amp

A_3………………. type Op Amp



Embedded Systems

1. ES1: Describe the architecture and main components for asymmetrical computation platform, with CPU and FPGA! Explain the connection of computer network components and schematic of analogue/digital Input/Outputs!

Ref:

R1. National Instruments, CompactRIO Developers Guide, ed. May 2009

Chapter 1: Machine Control Architecture Overview, Introduction to CompactRIO

Chapter 2: Basic Architecture for Control

R2: National Instruments, NI LabVIEW for CompactRIO Developer’s Guide

Overview and Background

LabView 2014 Examples:

Queue Message Handler Fundamentals.vi

CompactRIO Project Template: LabVIEW FPGA Control on Compact RIO

2. ES2: Describe the architecture and main components of a DAQ system: analogue parts, ADC, and digital processing with CPU. Please explain analog-to-digital conversion theory in time and frequency domain!

Ref: University of Oslo, FYS3240, PC based instrumentation and data acquisition, Spring, 2011, Lecture #6

LabView 2014 Project Template: Continuous Measurement and Logging

3. ES3:Describe an asymmetrical architecture (components, data paths, important states of each software component) of a control device with remote user interface. Please explain the state machine running on remote host, CPU and FPGA.

Ref: R2: National Instruments, NI LabVIEW for CompactRIO Developer’s Guide

Chapter 1: Designing a CompactRIO Software Architecture

LabView 2014 Project Templates: LabVIEW Real-Time Waveform Acquisition and Logging (NI-DAQmx)

4. ES4: What is a Real Time OS? Please explain soft and hard real-time features on CPU and FPGA. Please explain the main components and features of a Real-Time Operating System.

Ref: R2: National Instruments, NI LabVIEW for CompactRIO Developer’s Guide

Chapter 3 Designing a LabView Real-Time Application

LabView 2014 Project Templates: LabVIEW Real-Time Control (NI-DAQmx)

5. ES5: Data sharing and communication among embedded systems. Communication types: shared data, streams, queues, tags, shared variables. Low level (TCP/IP) based data communication. definitions of URL-s for data communication.

Ref: R2: : National Instruments, NI LabVIEW for CompactRIO Developer’s Guide

Chapter 4, Best Practices for Network Communication

LabView 2014 Examples:

- Butterworth Filter.lvproj (LPF on FPGA, no RT VI, UI on Host, FPGA access by URL!)

- Shared Variable.lvproj (different access techniques of shared variables)

- RT FIFO Variables – networked.lvproj (RT – Host FIFO communication)

6. ES6: Web services for embedded system. What is a web service, and web server? How to control user access? How to create web service in LabView for embedded systems.

Ref: R2: : National Instruments, NI LabVIEW for CompactRIO Developer's Guide

Chapter 4, Best Practices for Network Communication, Web Services only.

LabView 2014 Example: Web Services – Weather Monitor RT.lvproj

7. ES7: FPGA in embedded system. What is an FPGA and what the purpose of application? How to create FPGA resource in LabView? What is a scan engine, how does it work? Draw a simple state machine template in LabView for FPGA execution.

Chapter 2, Choosing a CompactRIO Programming Mode

LabView 2014 Example:

- Edge Counter.lvproj (FPGA only, no RT and no Host Vis)

- DC and RMS Measurement.lvproj (FPGA only, no RT and no Host Vis)

- PWM Generation.lvproj (FPGA only, no RT and no Host Vis)

- Butterworth Filter.lvproj (LPF on FPGA, no RT VI, UI on Host, FPGA access by URL!)

General resources for each question in Embedded Systems:

National Instruments, CompactRIO Developers Guide, ed. May 2009

National Instruments, NI LabVIEW for CompactRIO Developer's Guide

NI-RIO 14.0.1 NI-RIO Device Driver August 2014 f1 – for RIO based examples and project templates

http://www.ni.com/download/ni-rio-14.0.1/4862/en/