Masters of Mechanical & Automobile Engineering 1st Year 2nd Semester Examination

Subject: Control of Mechatronic Systems

Time : Three hours **Full Marks: 100**

Answer any **FOUR** *questions.*

1. Why a mechatronic system is so named and why is the system so constructed? Draw simple architecture in the form of connected block diagrams for a mechatronic system. Briefly mention the role of the important units shown in the block diagram. **7+10+8**
2. In terms of standard symbols, draw a closed-loop electrohydraulic motion-control system enacted by a double-acting single-rod cylinder with individual metering of the flow in the cylinder chambers. Between a large excavator and an aircraft, where is such a system preferred and why? **20+5**
3. Obtain a feedforward-PI controller design for an electrohydraulic motion-control system comprised of a vertical-axis double-acting double-rod cylinder, a zero-lap proportional valve, a fixed-displacement pump, a relief valve and other accessories. The piston should raise a heavy weight at constant speed and the friction between the cylinder and piston may be taken as proportional to the piston velocity. How many lands should be there in the proportional valve of this system and why? **20+5**
4. A payload of mass m undergoes a displacement x when a coil of resistance R and inductance L of a bi-solenoid motor is excited by a voltage V estimated by a PID controller routed through an amplifier of fixed gain K_a. Represent the transfer functions of the individual components through a block diagram. Obtain the overall close-loop transfer function for the response of the payload corresponding to a step demand, if the friction against the payload motion is negligible for the payload actuation by a force that is proportional to both the coil current and the payload displacement. **25**
5. (a) Find the equation to find the steady error from the transfer function of a system.. In terms of a system with first order numerator and second order denominator. Show that in a closed loop with unity feedback and a step input, the steady state error approaches zero in presence of an integral gain. **4+6**

   (b) Using Routh's Criterion, indicate the stability of the system with characteristic equation $s^6 + 2s^5 + 8s^4 + 12s^3 + 20s^2 + 16s + 16 = 0$. **15**
6. Starting from the general expression for the amplification factor and phase lag for a system of transfer function given by $G(s)$, sketch the corner plot and the corresponding actual variation for a linear system of positive coefficients with transfer function that has a first-order numerator and a second-order denominator. **25**